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THE EFFECTS OF POLLUTION ON A MIDWESTERN STREAM

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A year-round study of environmental conditions in the Mad River, one of the few trout streams in Ohio, was initiated in September, 1952. The objectives of the study were threefold: first, to determine how wastes discharged to the stream were affecting the physical-chemical environment; second, to determine the effects on the composition of the benthic-macroinvertebrate populations in the river; and third, to evaluate the significance of such organisms as indicators of ecological changes produced in the stream by pollution.

The Mad River is a tributary of the Great Miami River which enters the Ohio River near Cincinnati. It rises in Logan County, Ohio, and flows in a turbulent manner much of the distance to its confluence with the Great Miami and Stillwater rivers at Dayton. It is about 65 miles long and has an average gradient of six feet per mile. Its profile is typical in that the steeper slopes are in the headwaters and the flatter slopes are in the lower sections.

The 632 square mile drainage area of the Mad River contains the greatest concentration of permeable material in Ohio. Its course lies principally between two morainal ridges with extensive permeable drift covering the main valleys and uplands. In the neighborhood of Urbana, there are numerous small bog lakes and along much of the course of the river springs help to maintain a relatively high sustained flow. The major portion of ground-water inflow occurs between Springfield and Dayton.

The stream has been dredged and channeled between West Liberty and Tremont City, a distance of 20 miles. This section, as a result, has very few deep pools and presents many of the characteristics of a young stream.

In 1951 the Ohio Department of Health reported that four sewered municipal areas, with an estimated population equivalent (B.O.D.)* of about 150,000, discharged their wastes into the Mad River (McDill, 1951). All four have sewage treatment plants which, in 1949, were effecting a combined population equivalent reduction of about 40,000. Only the Fairborn plant provides secondary treatment.

The major portion of the wastes being discharged into the river comes from Springfield, a city of around 98,000 (1950 census). In 1949, the total wastes released from this source had a population equivalent of 75,000.

All sewage and industrial wastes from the city of Urbana, with an estimated population of 9,000, are discharged into Dugan Run about four miles upstream from its confluence with the Mad River. In Urbana several small manufacturing plants are connected to the municipal sanitary sewers and two large paper mills

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*Population equivalents as given by the Ohio Department of Health are based upon an average of 0.167 pound of 5-day, 20° C, B.O.D. per capita per day for domestic sewage.

discharge waste directly into Dugan Run. The total population equivalent of the Urbana area wastes in 1949 was 36,000 with 30,000 of this equivalent discharged into Dugan Run. Sewage from the town of West Liberty, 14 miles north of Urbana, is also discharged into the river, but contributed a population equivalent of less than 2,000.

PROCEDURES

During the course of this study, special attention was given to environmental variations accompanying seasonal changes such as floods, turbidity, bottom growth, temperature, pH, dissolved oxygen, and total alkalinity. Twelve stations, representative of the various sections of the stream, were selected for sampling

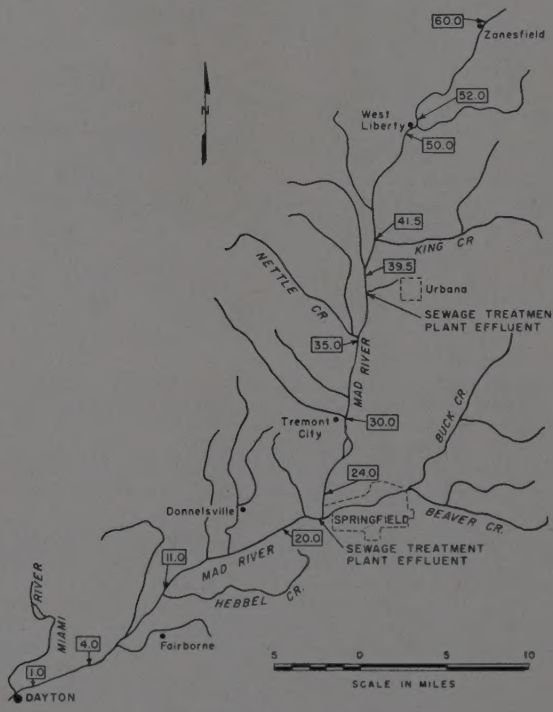

FIGURE 1. Mad River drainage basin.

purposes. The sampling areas also were selected to reveal seasonal changes in the stream above and below any major source of pollution. These stations are designated by the distance in miles upstream from the mouth (fig. 1).

Water samples were taken at each of these stations during October, 1952, January and May, 1953, and October, 1955, for the determination of dissolved oxygen, pH, CO_2, methyl orange and phenolphthalein alkalinity, and temperature. The samples taken in 1955 were used to determine changes which had occurred in the stream during the two-year interval following the initial year of the study. The follow-up study was prompted by several extensive fish kills noted between

Urbana and Springfield from 1953 to 1955. Diurnal variations in physical and chemical conditions were determined by taking hourly samples at six of the stations during November, 1952.

During each of the months listed, bottom samples were taken in pools, runs, and riffles. Collections to determine the relative abundance of different types of organisms in various sections of the stream were made with a Needham handscreen sampler 1 yard wide and 30 inches high. An area of bottom approximately 1 yard square was covered at each sampling, and the organisms collected were observed, classified, and enumerated in the field.

RESULTS

Physical and Chemical Conditions

The average annual precipitation for the Mad River watershed is approximately 38 inches, distributed fairly evenly throughout the year. However, from September 1952 to June 1953, precipitation was 7 to 10 inches below the annual average for that period. As a result of the decreased rainfall, only one scouring flood (May 17–22, 1953) occurred in the stream during the entire study.

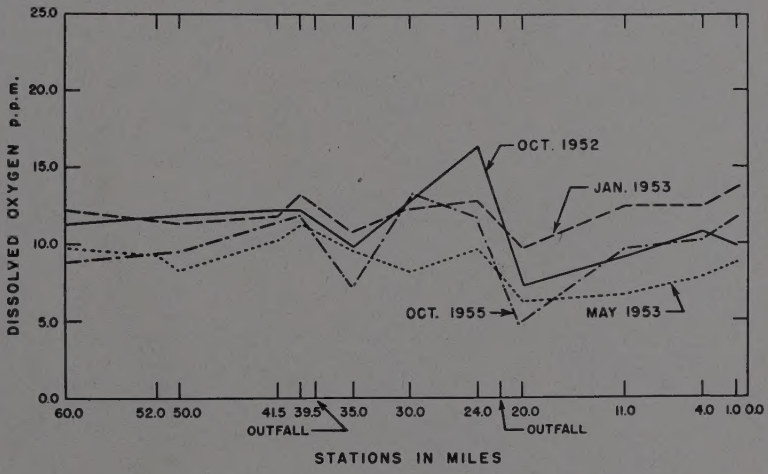

FIGURE 2. Variations in dissolved oxygen. Mad River.

Records of the U. S. Geological Survey (Paper 1275, 1953) showed considerable variation in the discharge from the river during the period October 1, 1952, to September 30, 1953. The maximum daily flow at Zanesfield near the headwaters was 170 c.f.s. on March 3; the minimum flow of 0.9 c.f.s. occurred on January 5 and 6 and during several days in September. At a point six miles above the mouth of the stream the maximum daily flow was 5,340 c.f.s. on May 23, and the minimum was 139 c.f.s. on September 30. These flows were $\frac{1}{3}$ to $\frac{1}{6}$ below the maxima and minima normally expected at these stations.

Because of the numerous springs that discharge into it, the temperature of the Mad River is cooler in spring, summer, and autumn and warmer in winter than other streams of comparable size in the area. For example, for September 1939, the Public Health Service (Report 517, 1942) reported the average temperatures of the Mad, Miami, and Stillwater rivers above their confluence at Dayton to be 63°F, 69°F, and 70°F, respectively. During January and February, 1953, the

Mad River averaged 42°F while the Miami and Stillwater rivers had 35°F averages. During May and early June 1953, the Mad River had a 63°F average, the Stillwater had warmed up to 70°, while the Miami averaged 78°F. As a result of its lower temperatures the Mad River supports a typical cold-water fauna, while the other two streams contain the warm-water species characteristic of the region.

Determinations of dissolved oxygen above and below the major waste discharges at Urbana and Springfield indicated a heavy organic load as there was a decrease in dissolved oxygen below the outfalls to less than 40 percent of saturation. After receiving the Urbana wastes, the dissolved oxygen content dropped 2 to 4 p.p.m., the amount varying with the temperatures and flow. Below Springfield the reduction was even greater, from 3 to 9 p.p.m. However, inspite of this reduction, the minimum dissolved oxygen value recorded was 3.8 p.p.m., or 34 percent of saturation. This concentration was encountered 20 miles downstream from

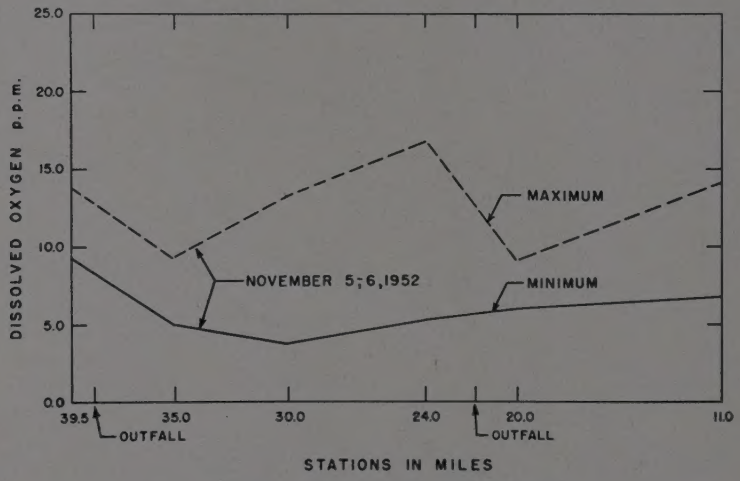

FIGURE 3. Range in dissolved oxygen. Mad River.

Urbana, at Tremont City, during a 24-hour sampling run conducted on November 5–6, 1952. It is probable that the dissolved oxygen content is lower than this during summer nights when temperatures are higher. Inasmuch as the river flow at Springfield on every sampling date was double to triple the critical flow of 125 c.f.s. determined by the Ohio Department of Health (McDill, 1951), oxygen depletion would undoubtedly have been much greater in September when the minimal flow was 120 c.f.s. for several days. A comparison of the dissolved oxygen concentrations in the stream under autumn, winter, and spring conditions is made in figure 2. The data points represent single grab samples taken during daylight hours. The diurnal variations in dissolved oxygen occurring above and below the major sources of pollution on November 5–6, 1952, are shown in figure 3.

Along with the decrease in dissolved oxygen there was a corresponding increase in free carbon dioxide. Free carbon dioxide concentrations of 2.6, 7.9 and 10.5 p.p.m. were obtained below West Liberty, Urbana, and Springfield, respectively in October 1955. No free carbon dioxide was found at any of the other stations during that period.

The pH of the river at the various stations varied so little as to be insignificant. The maximum pH value recorded was 8.4 in the daytime at several of the clean-water stations. The minimum of 7.5 was recorded above Springfield at night during the 24-hour run. Phenolphthalein and methyl orange alkalinity tests indicated the water to be rich in carbonates and bicarbonares, a condition which usually favors high productivity of bottom fauna and other life. The alkalinity of the water expressed as calcium carbonate content varied from a minimum of 249 p.p.m. at Zanesfield during May 1953, to a maximum of 341 p.p.m. in the lower part of the stream during October 1955.

Of the chemical factors considered, distribution of the stream fauna appeared to be more closely related to dissolved oxygen concentration than to any other factor noted. However, of equal or greater importance in the stream section below Urbana and Springfield was the influence of wood fibers in the paper mill wastes discharged at Urbana. Data supplied by the Chief Engineer of United Cardboard Co., during October 1955, revealed that each of the paper mills in that city releases 900,000 to 1,000,000 gallons of wastes per day directly into Dugan Run. Wastes from the two plants have a combined 5-day B.O.D. of 4,141 lbs. These wastes consist in part of a suspension of very finely divided paper particles carried in the wash waters from the plants. These particles gradually settle to the bottom of the river but they give a milky-white appearance to the water for a distance of 15 to 20 miles below the entry point. When settled, they form a blanket over the bottom and over anything else to which they can adhere. Few organisms can exist in this substratum because of suffocation and it is also unsuitable as an attachment base for most aquatic invertebrates.

Biological Conditions

In conducting this study, emphasis was placed on determining the effects of the wastes on the macroinvertebrate population of the river. The study was restricted to this group because of their larger size and more distinctive morphological characteristics which facilitate their identification under field conditions. In addition, it is believed that most representatives of the group have longer life histories than the microbenthic fauna and are thus better fitted for indicating past ecological conditions in any given area.

A total of 166 species representing 122 genera of macroinvertebrates were collected and identified during this study. This diverse fauna belonged to the following orders or families: mayflies (Ephemeroptera) 19 species; stoneflies (Plecoptera) 21; caddis flies (Trichoptera) 15; alder flies (Neuroptera) 3; beetles (Coleoptera) 24; dragonflies and damsel flies (Odonata) 9; water bugs (Hemiptera) 6; true flies (Diptera) 42; crayfish and shrimps (Crustacea) 5; springtails (Poduridae) 1; water mites (Hydrachnidae) 1; snails and clams (Mollusca) 8; leeches (Hirudinea) 3; segmented worms (Oligochaeta) 6; flat worms (Planaridae) 1; and round worms (Nematoda) 2.

The study revealed distinct differences in the number of species and the faunal associations occurring in the stream above and below the principal waste sources.

The largest number of species, 58, was taken in the clean headwater section above Zanesfield in May 1953. Nearly half of this number (47%) were species of mayflies, stoneflies, caddis flies, and beetles which were limited entirely in their distribution to the cleanest sections of the stream. No one species was found in numbers exceeding 25 per square yard while 27 species were represented by less than three individuals per square yard of bottom area. The average number of species of macroinvertebrates found in different sections of the stream on the four sampling dates is shown in figure 4.

The stimulatory effects of a moderate amount of organic enrichment on the productivity of the stream were clearly demonstrated below West Liberty. During the May survey, this station revealed only ¼ less species than were found upstream,

but four species exceeded 50 specimens per square yard, and one species, *Ephemerella simplex*, averaged over 100 individuals per similar size sample. The composition of the fauna, however, was changed decidedly with the disappearance of such stoneflies as *Isoperla transmarina*, and *Isogenus duplicatus*, and such caddis flies as *Chimarra obscura* and *Helicopsyche borealis*, and with the common occurrence of such facultative forms as *Chironomus decorus*, *Macrobdella* sp., and *Limnodrilus* sp. With adequate oxygen and an increased food supply, forms, characteristic of both clean water and organic enrichment, found niches in this environment which enabled them to thrive.

The limiting and selective effects of heavy organic enrichment on the fauna were most in evidence below Springfield. Not only was the number of species drastically reduced but the composition of the population was also greatly changed. The maximum number of species taken in this section was 14 in October 1952; the minimum number was 6 during the following January. With the exception of a single specimen of mayfly and caddis fly, all of the organisms encountered were those usually found in organically enriched areas. Those collected included the

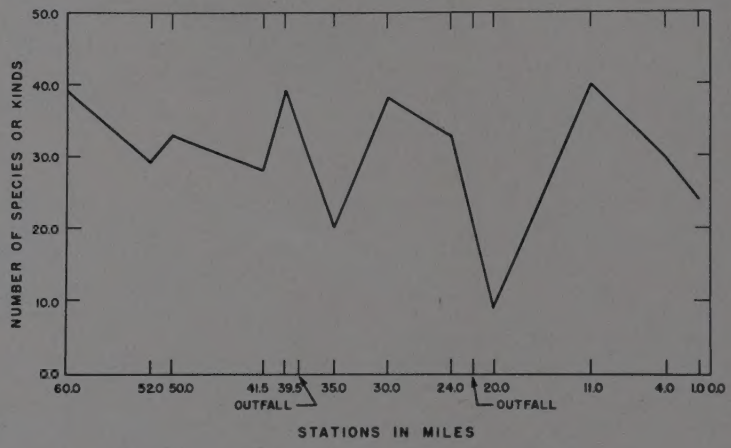

FIGURE 4. Macroinvertebrate distribution. Mad River.

pulmonate snail, *Physa integra*; sludge worm, *Limnodrilus* sp., leeches, Macrobdellidae, and red blooded midge larvae, *Chironomus riparius*, all of which occurred in large numbers. All of the organisms found in this section were characterized by special adaptations for obtaining oxygen or by very low oxygen requirements.

The movement of paper wastes downstream from Urbana between 1952 and 1955 resulted in some interesting changes in the faunal numbers and composition at several of the stations. In May, 1953, as many as 27 different species were taken at a point three miles below the confluence with Dugan Run, and 41 species occurred at Tremont City 5 miles farther downstream. By October 1955, these numbers had been reduced to 9 and 11 species, respectively. During 1953, such mayflies as *Baetis* sp., *Caenis* sp., and *Stenonema rubromaculatum*, and midge larvae of the subfamily Hydrobaeninae, were found in numbers exceeding 10 per square yard on the upper surface of floating masses of leaves of *Potamogeton* sp. While pulmonate snails, leeches, and sludge worms were common on the bottom, they did not exceed 20 specimens per square yard. By October 1955, all of the

mayflies and other gill breathing forms had disappeared and the remaining snails, leeches, and sludge worms had increased considerably.

At Tremont City in 1953, thirteen of the 41 species taken were mayflies, stoneflies, and caddis flies with *Caenis* sp. exceeding 100 per square yard. By 1955, all groups except midges (*Chironomus decorus*), water sow bugs (*Mancasellus* sp.), pulmonate snails, leeches, and sludge worms had disappeared.

At the beginning of the study in October 1952, the section of the river just above Springfield displayed the physical-chemical characteristics of an organically enriched stream but the macroinvertebrate fauna was still diversified. Forty-six species of macroinvertebrates were taken including 12 species of mayflies, stoneflies, and caddis flies. With the exception of large numbers of the mayfly, *Baetis* sp., which exceeded 150 per square yard, the stream supported a varied and well balanced aquatic community. By 1955, the number of species had been reduced to 15, but those that remained reached tremendous numbers. In the October 1955 survey, large numbers of *Hydropsyche* sp. (over 200 per square yard) existed in the faster, deeper riffles, associated with numerous *Mancasellus* sp. In the shallower riffles Planaridae were so abundant as to completely cover the hand screen in a single sample. In excess of 1,000 specimens were counted from one square yard. Associated with these forms were lesser numbers of pulmonate snails, leeches, and sludge worms.

The lower twenty miles of stream below Springfield showed much the same response to the added wastes throughout the course of the study. The section of stream north of Fairborn, or approximately 11 miles below the Springfield sewage treatment plant outfall, displayed a varied well balanced aquatic community at all times indicating complete recovery from the wastes received above. By the time the stream reached Dayton, however, after receiving additional wastes below Fairborn, most of the less tolerant mayflies, caddis flies, and stoneflies had disappeared.

DISCUSSION

As stated previously, there were three principal objectives of this study. The effects of organic enrichment on the physical-chemical environment and on the benthic macroinvertebrate population in the river have already been presented. An evaluation of such organisms as indicators of the ecological conditions under which they existed in various sections of the stream will now be discussed.

Numerous lists of indicator organisms have appeared in various publications (Richardson, 1921, 1928; Mackenthun et al., 1956; Weston and Turner, 1917). In other investigations, the pollutional zones have been indicated by means of diagrams showing the percentage of so-called clean-water, facultative, and pollutional forms occurring in the areas studied (Surber, 1953; Wilson, 1953). Many of these lists have been based on the ecological classification originated by Kolkwitz and Marsson (1908, 1909) and later published by Whipple (1948). Comparison of these different lists will show that there is an appreciable lack of agreement as to the true status of many of the organisms. This lack of agreement is a result of regional differences in the species present and in the environment, and is conditioned by the point of view of the investigator, the mechanism of evaluation, the types of pollutants, and other factors.

A satisfactory classification of organisms as indicators of organic enrichment depends upon several criteria. These criteria have been discussed in more detail by Gaufin and Tarzwell (1952), but are briefly presented here to emphasize some of the difficulties involved in classifying organisms into definite "pollutional" categories. Many organisms which occur in large numbers in extremely enriched areas may also be found in limited numbers in cleaner situations. In this connection, it should be pointed out that the mode of occurrence of the forms is just as important as their presence or absence in a given area. For example, while a few

specimens of *Physa integra*, *Macrobdella*, and *Limnodrilus* were found in certain microhabitats in the clean water areas in the Mad River, they were found in much larger numbers (50 or more per square yard) and occupied considerably more space in the organically enriched sections. This was due to an increased food supply as well as a decrease in competition caused by the elimination of intolerant species.

In differentiating between clean water and facultative forms, it is likewise important to consider the numbers represented and adaptations involved. An occasional mayfly, stonefly, or caddis fly may be found during winter in stream sections which are septic in summer. When these insects drift into such a stream from nearby tributaries, they may live for considerable periods of time because the septic zone of summer often has acquired an adequate dissolved oxygen supply during winter. Before such isolated examples are taken as evidence that the forms involved are facultative, an investigation as to their source and their abundance in the source area is advisable.

Consideration of the structural and physiological adaptations is often very important in arriving at a better definition of the habitat preference of the forms being considered. In general, air breathers are not limited by deficient dissolved oxygen and can be considered tolerant of environmental conditions produced by excessive organic enrichment. Conversely, most gill breathers are dependent directly upon the amount of dissolved oxygen available in the water and are intolerant of any environmental change which reduces the dissolved oxygen level below their requirements.

At the beginning of this study, the sources and extent of organic and industrial pollution in the river were initially determined by reference to data published by the Ohio Department of Health (McDill, 1951). This information was later confirmed by direct observations and by chemical and physical data collected during 1952–53 and 1955. No additional waste treatment facilities had been installed by any communities or industries along the river since the Health Department Survey. Below Springfield for at least five miles the river displayed a grayish color and produced foul sewage odors; sticky blackened sludge deposits with offensive odor were everywhere in evidence, and gas bubbles could be seen rising frequently from deep pools during the warmer months. The stream below Urbana was milky white for a distance of 15 to 20 miles and black sludge deposits were common in pools and in *Potamogeton* beds in the entire stretch between Urbana and Springfield, particularly during October, 1955.

Dissolved oxygen concentrations in the stream just below the Urbana sewage outfall to three miles below Springfield varied during the night of the 24-hour sampling run conducted on November 5–6, 1952, from 34 to 53 percent of saturation. Following Suter and Moore's (1922) classification of zones of pollution and self purification, this entire section of stream constituted the lower end of a zone of degradation or the upper end of a zone of active decomposition.

In classifying the organisms collected during the study, citations in the literature, mode of occurrence, relative abundance, physiological and morphological adaptations, and number of records of each species were taken into account. Species averaging more than 50 specimens per square yard were considered numerous, those ranging from 5 to 50 per square yard were common, and those occurring less abundantly than 5 per square yard, scarce or few. The species or genera of organisms collected, their distribution according to Suter and Moore's pollutional zones, and their pollutional classification are given in table 1.

In comparing the indicator status of the Mad River specimens with citations of the same species in the literature, it was found that the environmental classifications selected by the author were in fairly close agreement with those given by Schiffman (1953) for Illinois fauna, by Mackenthun et al. (1956) for Wisconsin, and by Surber (1953) for Michigan. However, over half the material collected

TABLE 1

Distribution of macroinvertebrates, Mad River, 1952–53, 1955

Intolerant Organisms*

Ephemeroptera (14)
Ephemera simulans, Ephemera guttulata, Ephemerella simplex, Ephemerella sp., *Heptagenia maculipennis, Heptagenia* sp., *Hexagenia limbata, Isonychia* sp., *Leptophlebia* sp., *Paraleptophlebia* sp., *Potamanthes* sp., *Stenonema interpunctatum, Stenonema tripunctatum, Stenonema rubromaculatum.*

Plecoptera (20)
Acroneuria evoluta, Allocapnia granulata, Allocapnia nivicola, Allocapnia recta, Allocapnia viviparia, Alloperla mediana, Brachyptera fasciata, Hastaperla brevis, Isoperla bilineata, Isoperla confusa, Isoperla decepta, Isoperla minuta, Isoperla transmarina, Isoperla orata, Isoperla signata, Isogenus duplicatus, Neophasganophora capitata, Nemoura sp., *Paragnetina media, Perlesta placida.*

Trichoptera (10)
Caborius sp., *Chimarra obscura, Glossosoma* sp., *Helicopsyche borealis, Hydroptila* sp., *Hydropsyche* sp., *Hydropsyche slossonae, Pycnopsyche* sp., *Rhyacophila lobifera, Rhyacophila fenestra.*

Hemiptera (2)
Mesovelia sp., *Microvelia* sp.

Neuroptera (2)
Chauliodes sp., *Sialis* sp.

Coleoptera (5)
Helichus lithophilus, Psephenus lecontei, Stenelmis crenata, Stenelmis sexlineata, Simsonia quadrinotata.

Diptera (13)
Calopsectra sp., *Cricotopus tricinctus, Cryptochironomus* sp., *Corynoneura* sp., *Limnochironomus* sp., *Microtendipes pedellus, Polypedilum illinoense, Stictochironomus* sp., *Anopheles punctipennis, Antocha* sp., *Eriocera* sp., *Pseudolimnophila* sp., *Paradixa* sp.

Hydrachnidae (1)

Facultative Organisms**

Ephemeroptera (5)
Baetis spp., *Caenis* spp., *Stenonema ares, Stenonema heterotarsale, Stenonema pulchellum.*

Plecoptera (1)
Taeniopteryx maura.

Trichoptera (5)
Cheumatopsyche sp., *Hydropsyche bronta, Hydropsyche betteni, Hydropsyche cuanis, Hydropsyche simulans.*

Odonata (9)
Agrion maculatum, Argia sp., *Enallagma* sp., *Ischnura* sp., *Hetaerina americana, Boyeria vinosa, Dromogomphus* sp., *Progomphus* sp., *Libellula lydia.*

Hemiptera (4)
Belostoma sp., *Gerris* sp., *Hesperocorixa* sp., *Notonecta* sp.

Neuroptera (1)
Corydalis cornutus

Coleoptera (19)
Agabus stagninus, Berosus sp., *Dineutes americanus, Enochrus pygmaeus nebulosus, Haliplus* sp., *Hydroporus* sp., *Hydroporus wickhami, Hydroporus mellitus, Laccobius agilis, Laccophilus* sp., *Laccophilus fasciatus, Laccophilus maculosus, Peltodytes* sp., *Peltodytes 12-punctatus, Peltodytes edentulus, Peltodytes lengi, Paracymus* sp., *Tropisternis lateralis, Tropisternis natator.*

Diptera (28)
Anatopynia decolorata, Anatopynia dyari, Chironomidae (unidentified), Chironomini, *Chironomus decorus, Cricotopus* sp., *Cricotopus bicinctus, Cricotopus trifasciatus,* Hydrobaeninae, *Hydrobaenus nivoriunda, Chironomus* sp., *Metriocnemus* sp., *Pentaneura melanops, Polypedilum fallax, Polypedilum* sp., *Procladius* sp., *Atherix* sp., *Palpomyia flavipes, Tipula abdominalis, Chrysops* sp., *Tabanus* sp., *Argyra* sp., *Rhoderiodes* sp., *Limnophora* sp., *Simulium vittatum, Simulium* sp., *Stratiomys discalis, Ephydra* sp.

Crustacea (5)
Orconectes sp., *Asellus* sp., *Mancasellus* sp., *Gammarus* sp., *Hyalella* sp.

Poduridae (1)
Podura sp.

Mollusca (5)
Ferrissia sp., *Goniobasis* sp., *Helisoma* sp., Pleuroceridae, *Pisidium* sp.

TABLE 1—(*Continued*)

Hirudinea (1)
Glossiphona sp.
Oligochaeta (2)
Aeolosoma sp., *Helodrilus chlorotica*
Nematoda (1)
Paragordius sp. (1)

Tolerant Organisms***

Diptera (1)
Chironomus riparius
Mollusca (3)
Musculium sp., *Sphaerium* sp., *Physa integra*
Hirudinea (2)
Macrobdellidae, *Macrobdella* sp.
Oligochaeta (4)
Dero sp., *Limnodrilus* sp., *Tubifex* sp., Lumbriculidae
Planaridae (1)

*Largely restricted to Clean Water Zone: Dissolved oxygen between 75%–115% of saturation (Hwy 33, N.W. Liberty, Hwy 36, Hwy 29).

**Found in both Clean Water Zone and Zone of Degradation: Dissolved oxygen between 40% to 115% of saturation (Hwy 68, S.W. Liberty, Hwy 235, North Dayton, Hwy 69, Tremont City (1953), Hwy 70 (1953).

***Most abundant in Zone of Active Decompositions: Dissolved oxygen between 1% to 40% of saturation (Hwy 55, Lower Valley Pike, Tremont City (1955), Hwy 70 (1955).

from the Mad River was not classified in the literature consulted, thereby eliminating any chance for comparison of such specimens.

Reference to table 1 will reveal that most of the species classified as being intolerant are mayflies, stoneflies, caddis flies and other strictly gill breathing forms which were restricted to the clean water sections of the stream. Two or three records of a gill breathing species occurring in very limited numbers in the non-clean water zones were not considered sufficient to change its classification to the facultative category. If, however, such a species was common or numerous in the zone of degradation or zone of active decomposition and was evidently a resident form, it was considered as being facultative. Such species as *Stenonema ares*, *Taeniopteryx maura*, *Hydropsyche betteni* and *Corydalis cornutus* were found to be surprisingly tolerant of organic enrichment and were placed in this category.

Most of the surface breathing beetles and water bugs such as *Tropisternis natator*, *Peltodytes lengi*, *Laccophilus maculosus*, *Hesperocorixa* sp., and *Belostoma* sp. were found in both clean and polluted areas in about equal numbers and were also classified as being facultative. Their abundance depended primarily upon the availability of food, suitable cover, competition, etc., and their method of respiration made them largely independent of the dissolved oxygen supply.

Approximately one-third of the organisms considered as being facultative were Diptera. Representatives of this order were found in the stream in both the clean water and polluted zones in many ecological niches. However, two-thirds of the species collected were more abundant in the Zone of Degradation than elsehwere. Their ability to thrive in the presence of considerable organic pollution is due to the possession by some species of special respiratory tubes for obtaining oxygen from the surface, to the presence in others of hemoglobin for storing and transporting oxygen, or to very low oxygen requirements.

Comparatively few species were encountered which could be considered as "pollution" preferring forms. Such invertebrates as the midge larvae, *Chironomus riparius*; pulmonate snail, *Physa integra*; leech *Macrobdella* sp., and sludge worms, *Limnodrilus* sp. and *Tubifex* sp., while present in limited numbers in clean waters, were found so abundantly and predominately in the most heavily enriched sections that they could reasonably be called pollutional species.

In conclusion, populations dominated by the gill-breathing insects such as mayflies, stoneflies, and caddis flies were largely restricted to the clean water sections of the stream and their absence denoted excessive organic pollution or low dissolved oxygen. Likewise, the presence of a population consisting primarily of species adapted to live under very low dissolved oxygen levels as *Tubifex* and *Limnodrilus*, or those able to secure their oxygen directly from the air as do *Culex pipiens*, *Eristalis bastardi*, and *Physa integra*, was equally indicative of heavy organic pollution.

SUMMARY

A year-round study of environmental conditions in the Mad River was conducted by the writer during 1952–53. The period was unusually dry, resulting in a precipitation deficiency in the drainage basin from 7 to 10 inches below the annual average of 38 inches. As a result, the average flow of the stream was only half the annual average reported for the preceding seven years.

Because of numerous springs which discharge into it, average seasonal temperatures of the river were found to be 7° to 15°F lower than in streams of comparable size in the area. Chemical analyses of water samples taken above and below the major sources of pollution at Urbana and Springfield reflected the waste discharge by a decrease in dissolved oxygen of from 2 to 9 p.p.m. and a corresponding increase in free carbon dioxide from 0.0 to a high of 10.5 p.p.m.

Of equal importance were the effects of paper mill wastes discharged at Urbana. Each of the paper mills in that city releases between 900,000 to 1,000,000 gallons of waste per day into Dugan Run, a tributary of the river. These wastes have a combined 5-day B.O.D. of 4,141 lbs. In addition they blanket the bottom with paper fibers, making it totally unsuitable as a habitat for most species of macroinvertebrates.

A total of 166 species representing 122 genera of macroinvertebrates were collected and identified. The largest number of species, 58, was taken in the headwater section above Zanesfield in May 1953. Nearly half of this number (47%) were mayflies, stoneflies, caddis flies, and beetles, and were limited entirely to the cleanest sections of the stream. The selective effects of heavy organic enrichment on the fauna was most in evidence below Springfield. Only 14 species were collected at any one time in this area and, with the exception of one mayfly and one caddis fly, all of the organisms encountered were what have been classified as facultative or polysaprobic forms.

The movement and accumulation of paper wastes downstream from Urbana between 1952 and 1955 resulted in some interesting changes in faunal numbers and composition at several of the stations. In May 1953, as many as 27 different species were taken three miles below Urbana, 41 species occurred 5 miles farther downstream, and 46 species were collected just above Springfield. Included were 12 species of mayflies, stoneflies, and caddis flies. By October 1955, these numbers had been reduced to 9, 11, and 15 species respectively, and all gill breathing forms except one species of *Hydropsyche* had disappeared. This form was found only in fast riffle areas. The leeches, snails, sludge worms, and water sow bugs that remained occurred in tremendous numbers.

By considering the species composition, abundance, and adaptations of the macroinvertebrates collected in the various pollutional zones which were indicated by physical-chemical tests, it was possible to classify such organisms into three categories based upon their reactions to organic enrichment, clean water, facultative, and pollution-preferring categories. Nearly 50 percent of the species taken in the river above Urbana were clean water forms, with less than 10 percent of the pollution-preferring species represented. By contrast, 50 percent to 100 percent of the macroinvertebrates occurring below Urbana during the 1955 survey were "pollution-tolerant" forms with no clean water forms present immediately below Urbana and Springfield.

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Principles of Biology. 2nd Ed. *W. Gordon Whaley, Osmond P. Breland, Chalres Heimsch, Austin Phelps,* and *A. R. Schrank.* Harper Brothers. x+877 pp. $6.75.

This textbook is designed for use during an entire college year, and it presents Biology instead of Botany and Zoology in such a manner that students are saved the usual loss of time in learning some fundamentals which are usually presented in *each* of these related fields of science. The subject matters are presented so students will think of the structures and functions of plants and animals. For example, one part deals with development and growth, of aging and death, as processes to be seen in both kinds of organisms. The part which presents the facts and principles concerning the interrelationship of organisms and the relation of organisms and environment follows the combined treatment more effectively than the usual presentation of plant or animal ecology.

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THOMAS H. LANGLOIS

WISCONSIN AGE FORESTS IN WESTERN OHIO
I. AGE AND GLACIAL EVENTS

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BACKGROUND

Twenty-nine dates have been determined by radiocarbon analysis for buried wood materials in western Ohio and immediately adjacent areas. This is an attempt to fit known stratigraphy to the dates. Since the dates are internally consistent, their accuracy is not challenged. Interpretation of the stratigraphy of each collecting site and a careful study of the nature and condition of the former vegetation are combined in this pair of papers (Parts I and II).

Most of the study of the glacial drifts in this part of the state is under the geological program of the Water Division, Ohio Department of Natural Resources. It was begun in 1946 and has been pursued by field study from one to three months of each year and supplemented by master's and doctorate studies at The Ohio State University. All C^{14} dates were determined by the University of Chicago Institute for Nuclear Studies (Arnold and Libby, 1951; Libby, 1951, 1954), the U. S. Geological Survey's Radiocarbon Laboratory (Suess, 1954; Rubin and Suess, 1954, 1956), the Yale University Geochronometric Laboratory, the Michigan University Radiocarbon Laboratory (Crane, 1956), or Lamont Geological Observatory (Broecker, Kulp, Tucek, 1956). The botanical study of the dated wood and other buried forest litter was initiated in July, 1954, and continued in July-August, 1956, by Dr. Burns for the Ohio Water Division.

Logs have been recovered from the glacial drift of Ohio by well-digging operations during more than a century. A few old samples are retained in museums, but most are lost. Well drillers today turn in reports of buried wood at the rate of nearly one a month. With the advent of radiocarbon dating these take on new importance so all finds are being reviewed and some old samples dated. However, most samples must be found by visiting known localities, old and new, where stream or road cuts expose forest material. Thousands of excavations in till have been searched by the detailed mapping of 17 counties but these netted only 10 new localities. On the other hand, where buried wood is found there are usually a great many logs.

The 26 dated deposits in and near western Ohio fall into three groups, more or less as classified by Flint and Rubin (1955). These are (1) those which are greater than 32,000 years old and fall generally beyond the limit of accurate C^{14} dating. They always lie completely *underneath* one or more till sheets. Then, (2) a large group falls scattered over a period 16,600 to 27,500 years ago, and the materials are found *within* multiple till sheets. And finally, (3) a group in the upper washed drift or in bogs and lakes *on top of* till dates from 14,500 to 8,500 years ago. Each group is separated from the other by a void of 2,260 years or more, yet within each group nearly every one thousand years is represented by a specimen or two. The periods devoid of samples probably represent ice cover either stable or in retreat.

OLDEST MATERIALS

C^{14} Date	Number	County	Village	Landmark	Collector*
>40,000	W–152	Clark	N. Hampton	E. Br. Honey Crk.	Brown
>37,000	W–415	Shelby	Kirkwood	Brush Creek Cut	Forsyth
>34,000	W–96	Montgomery	Germantown	Twin Creeks Cut	Orton?
>37,000	W–263	Franklin	Gahanna	Rocky Fork Cut	Goldthwait
>32,000	W–100	Elgin, Ont.	Port Talbot	L. Erie bluff	Dreimanis
>33,000	L–185A	" "	" "	" "	Dreimanis
>38,000	L–217A	" "	" "	" "	Dremanis

*In published C^{14} lists the man who submitted the sample is listed; here the original collector is noted if possible.

DRIFT STRATIGRAPHY

These five scattered localities (circle spots on fig. 1) are similar in one way. Each one represents a separate interstadial bed—not material swept up in till, as were most mid-Wisconsin logs. Each one lies below two to four thick till layers. At Port Talbot (W–100, etc.) there is a gyttja containing pollen of jack pine, spruce, larch, and birch (Dreimanis, 1953, p. 1414) with two widespread till sheets over it. At Kirkwood (W–415) thin peat lies on leached and reduced gravel soil 3 to 5 feet deep. At Gahanna (W–263) spruce wood is in cross-bedded (late glacial ?) sand overlain by two distinct tills. At Germantown (W–96) the bed is peat 3 to 20 feet thick, which continues at 30 to 90 feet depth from well to well for as much as one and two miles away. Until about 1900 this peat was visible

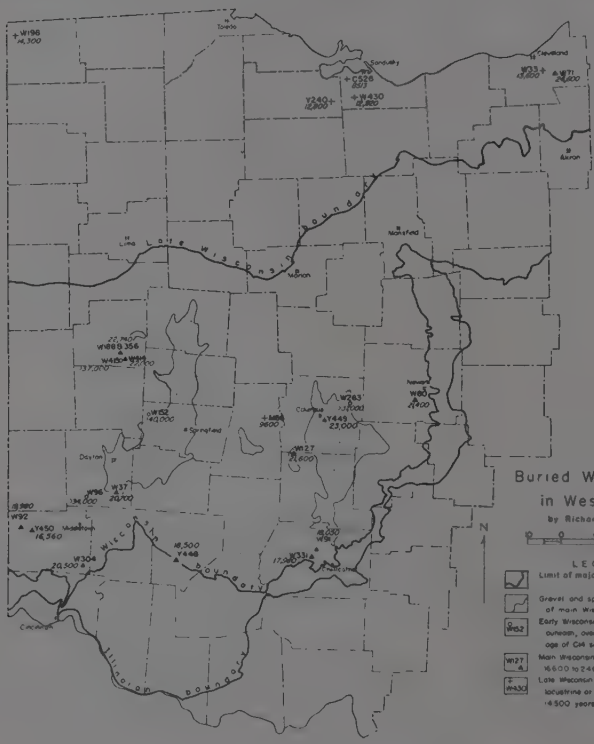
Buried Wood Localities
in Western Ohio
By Richard P Goldthwait
Scale
LEGEND
Limit of major glacial advance
Gravel and spots of soil buried under till of main Wisconsin advance
Early Wisconsin(?) interstadial, wood in peat or outwash, over 32000 years old Number indicates age of C14 samples
Main Wisconsin advance, wood in till or varves, 16600 to 24600 years old
Late Wisconsin wood, an upper fill but in glacio lacustrine or outwash deposits, 8900 to 14500 years old

FIGURE 1. See text.

lying on two feet of blackish soil, leached, and grading to gravels with ghost dolomite pebbles below—evidently a gley soil. Based on similarity of development and condition, it is tempting to say that these four represent one and the same interstadial time; until shown otherwise that is the simplest hypothesis.

Two of these sites yield only trees indicating moist, cool climate (pp. 220–21). However, the vegetation in North Hampton (W–152) lacustrine beds and Germantown peat suggests these were warmer (pp. 220–21). The superposition of the till

is in question at North Hampton, too, since it is not exposed above the lacustrine beds, but only over sand 70 feet north and on higher slopes. At the Germantown locality (W 96), Orton (1870) quotes nonexpert identification of ash, hickory, and sycamore wood with grape and beech leaves. These two sites mark distinctly warmer conditions which might stem from an earlier part of the same interglacial time, or from an earlier interglacial time.

W–263 (>37,000)
Franklin Co., Gahanna

Rocky Fork Crk.
SE¼ SW¼ Section 2

2½–4′	*soil*, Miami A, B
10–15′	*till*, brown, sandy NNE source, 28–44% ss, sh sandstone boulder pavements
14–25′	*till*, gray, silty WNW source, 33–49% dolomite
12–21′	*sandy gravel*, outwash? *wood* 1′ from top upper: 4′ rusty sand, cross bedded middle: coarse, cross bedded, gravel bottom: sand
9–18′	*till*, blue gray, clay rich NW source, 22–33% ls
20′	*bedrock*, red, Bedford shale west end only

W–100 (>32,000), L–217A (>38,000) etc.
Elgin (Ont.)
Port Talbot

2″	*soil*
19′	*clay*, lacustrine
8′±	*till*, clay rich, pale brown local SE source, 5–9% Pre-Cambrian
12′	*clay*, lacustrine
45′±	*till*, sandy, pebbly, olive gray (*wood*, 12′ below top at Plum Point) NE source, 17–25% Pre-Cambrian
½′	*gyttja*, W–100
	silt, calcareous (*varved clay* and *till*)

W–96 (>34,000)
Montgomery Co., Germantown

Twin Creeks
SE Section 18

8′	*soil*, Miami A, B, C
18–29′	*till*, mostly gray
5–6′	*till*, yellow, lenticular silt lenses along outcrop
20–40′	*till*, blue gray (other yellow tills described by Leverett)
*(0–20′	*peat*, saucer shaped lens 225′ long, compressed logs)
(2′	*soil*, black top, ghost dolomites leached)
(10′+	*gravel*, calcareous)

W–152 (>40,000)
Clark Co., N. Hampton
Marquart Rd. at St. Paris Rd.

E. Branch Honey Crk.

0–36′	silty clay *till* on slope
3–5′	medium coarse *sand* poor laminations
2½′	fine *sand and silt* sand lenses 5 layers of *leaves* and *twigs*
¼″	medium coarse *sand*
3′+	limestone *bedrock*

*Layers in parentheses not visible in the last decade.

W–415 See section listed for W–414

Two of these localities rest on significant gley soils. Each is developed in gravel, and pebbles are well rotted, but each soil is thin and only weakly acid. There is no sign of long interglacial time as is implied by this typical Sangamon soil in a ditch at New Martinsville, Clinton Co.:

2½′	*silt*, loess, Wisconsin with weathered profile, brown
3½′	*clay*, humic gley soil, gumbotil, gray, acid
2½′	weathered *till*, yellow, leached
1′+	*till*, calcareous, gray

Since the capping peat is present on three of these dated sites, there was no mass removal of the A zone by ice here, and we are forced to the conclusion that this was a mostly cool moist interval of perhaps 5 to 15 thousand years duration.

THE AGE ARGUMENT

Both the absolute age and the glacial stage name to be applied to these lower glacial gravels and tills have been questioned. On the one hand, there are dates on the earliest *known* Wisconsin materials from Illinois to the west which suggest the Farmdale is 22,000 to 25,000 years old, or the Tazewell is 16,000 to 22,000 (Horberg, 1955; Ruhe and Scholtes, 1955). No matter which assignment is more nearly correct, these do not account for a Wisconsin substage glaciation before 30,000 years ago. On the other hand, dating of high lake levels in southwestern United States, dating of soils in the Rocky Mountains (Richmond, 1955), dating of glacier advances in Alaska (Karlstrom, 1957), dating of the cooler sea floor layers (Ericson and Wollin, 1956), and many European "Wurm" datings indicate two cold periods in post Sangamon time, the earlier of which is more than 35,000 or 40,000 years ago.

The crucial questions in Ohio are: How long a time is represented by the buried soil? Are the buried soil and associated layers distinctive enough to be recognized as one common soil everywhere, or do they represent several soil-forming episodes? Only the most brief summary of ten seasons of stratigraphic study is possible here.

The first outstanding fact is that from Columbus to Circleville, down the Scioto Valley, east into Licking County, west around London, and down the Mad River-Miami Valleys from Logan County to Butler County there are 1,200 square miles where every well and many exposures reveal till over gravel (stippled areas on fig. 1). The till-smeared rolling surface near Bellfontaine clearly expresses kames and kettles underneath; half-exposed kames and eskers are known southeast of Columbus and Circleville. Where wells go deep enough, thin till layers sometimes occur in the gravel and till is usually present below it, but closely related in time. So many hundreds of well records are available at the Water Division that the general continuity of the gravels in the till "sandwich" can hardly be questioned. These are traceable in wells to the gravels which bear wood over 37,000 years old at Gahanna. Clearly the ice came once, leaving lower till, and then poured out gigantic outwash deposits as it left, for these buried esker, kame, and outwash forms surpass anything elsewhere in Ohio glacial drift. Then ice returned for its main and final call of several pulsations shown by several upper tills, well dated at 24,600 to 16,600 years ago (next section).

The second pertinent observation is that at more than 45 separate actual exposures (in the areas of dots on fig. 1) there is a buried "soil" on the gravel, consisting of 0 to 4 feet of *leached* and red-clay-enriched upper gravel. It is horizontally extensive, but discontinuous, right under the upper *calcareous* tills. Dozens of soils experts and many geologists have inspected these; the concensus is that many of them are genuine buried soils. If some are, all may be. Extensive laboratory tests are being run and will be reported later, but the depth, clay content and texture are very similar to that for modern postglacial Fox soils in gravel. Only at the Sidney cut (W-188) found by Forsyth is this underlying soil developed in till. Here it is leached 1½ to 4 feet and is much like some Miami soils in clay-content, acidity, structure, and depth. Forsyth has shown that it differs markedly from the Illinoian soils (Forsyth and LaRocque, 1956). While these might be truncated by later ice advance, they still do not resemble lower parts of Sangamon soils in southern Ohio (p. 211). The similarity of stratigraphic position of all these soils, their thinness, the like gravels in which they are developed and the continuity of the gravels suggest that these represent one and the same period. The soils do not demonstrate a long interglacial period and circumstantial

evidence favors the simplest hypothesis that they represent one interstadial period occurring during 5 to 15 thousand years between two long major glacial advances of the Wisconsin stage.

Another line of evidence tests this hypothesis. In the Hocking Valley, Kempton (1956) found a terrace level, traceable for 40 miles. It is well above known Wisconsin terraces (4′ deep Fox soils), but well below Illinoian terraces (15′ deep Hocking soils), and it can be identified by its high count (38%) of clastic local pebbles, and its 6 to 8 ft leached brown soil. The lower Wisconsin terrace, on the other hand, is correlated with the 20,000 year old drift at Lancaster, Ohio (Conley, 1956), so this older higher post-Illinoian terrace must be "early" Wisconsin.

MID-WISCONSIN FORESTS

C^{14} Date	*Number*	*County*	*Village*	*Landmark*	*Collector*
27,500±1,200	W–177	Elgin, Ont.	Tyrconnell	Plum Point	Dreimanis
26,000±1,000	L–185B	"	"	" "	"
24,600±1,500	L–217B	"	"	" "	"
24,600±800	W–71	Cuyahoga	Cleveland	Clev. S. & G. Co.	White
23,000±850	Y–449	Franklin	Columbus	4th St. at Long	Goldthwait
23,000±800	W–188	Shelby	Sidney	B & O RR cut	Forsyth
22,400±800	W–356	"	"	"	Rubin
22,000±1,000	W–414	"	Kirkwood	Brush Crk.	Forsyth
21,600±1,000	W–127	Pickaway	Harrisburg	U S Rt. 62	Frye, J. (?)
21,400±600	W–88	Licking	Newark	Kaiser l.A Co.	Mahard
*(>16,100±850	C–893	"	"	"	")
20,700±600	W–37	Montgomery	Southern Hills	Hole's Crk.	Goldthwait
(>17,000	C–508	"	"	"	")
20,500±800	W–304	Butler	Westchester	E. Fk. Mill Crk.	Rich
19,980±500	W–92	"	Oxford	Bull Run	Goldthwait
(>15,000	C–456	"	"	"	")
18,500±420	Y–448	Clinton	Cuba	Faris Rd.	Sanderfur
18,050±400	W–91	Ross	Chillicothe	Biers Run	Goldthwait
17,980±400	W–331	Ross	Anderson	Anderson Run	"
16,560±230	Y–450	Butler	Darrtown	Fourmile Crk.	"

*(Those in parentheses considered less reliable for calculations.)

Stratigraphy.—These 14 sites (triangle spots on fig. 1) have many features in common. The logs are all in till, mostly near the base of a till layer, except W–71 in varved proglacial clays. There are bedded sand or gravel lenses with limonite-hematite staining in the till near every group of logs. These masses often have low dips or are contorted, suggesting that they were picked up frozen and twisted. The logs themselves are bent and in some cases doubled back like oxbows indicating powerful differential twisting within the ice-till mass itself. Only casual measurement of pebble orientation has been attempted and these indicate a strong till fabric. In every case except two (W–188 and W–177) the discovery log led to the finding of many more pieces nearby; in other words, logs come in groups. Part II will show that the pieces represent one uniform kind of cold-weather forest.

From these facts of situation, it is highly probable: (*1*) that these record the last major glacial *advance* with pulsations across western Ohio; (*2*) that here and there the ice pushed into extensive patches of living forest; (*3*) that these forests developed in cool pro-glacial climate like north central Ontario; (*4*) that the same ice picked up masses of already sorted sand and gravel, so the forests were closely associated with outwash materials now found beneath the upper tills; and (*5*) that the ice squeezed and contorted the till, gravel and logs by differential shearing motions or fluxing currents of ice.

The specific stratigraphic situation varies from site to site. The group of 5 simplest sites lie under gently undulating smooth till surface mapped as ground

moraine. The wood occurs near a contact with a gravel lens. Inasmuch as the wood was alive when picked up these represent the time of last recorded ice advance at these spots.

W–91 (18,050±400)
Ross Co., Chillicothe
Biers Run,
½ Mile NW of US 35

8′	*soil*, Miami A, B, C in bank above floodplain
10–25′	*till*, gray, compact where creek cuts high bank
	otherwise, 2–3″ *sand*, alluvial, silty, where creek has migrated
3–7′+	*till*, gray, compact numerous sand lenses to 20′ long laminated, some contorted limonite crusted *logs* (over 200 seen) some against gravel twisted black pods of forest litter

Y–449 (23,000±250)
Franklin Co., Columbus
2 blocks NW of Capitol
4th St. at Long St.

(?	*soil* removed in previous building)
15′	*till*, gray *wood* at very base partially replaced by pyrite
50′±	*gravel*, bedded

Y–450 (16,560±230)
Butler Co., Darrtown
Fourmile Creek cut
SE¼ SE¼ Section 31
Lane's Mill (and ½ mile NE)

9′	*soil*, except to NE on low bank under floodplain, 5–8′ silty gravel instead
10–28′	*till*, gray sand lenses 1–3′ thick *wood* near base abundant
(0–3′	*peat*, lens 45′ long now covered or gone)
(25′+	*till*, now covered)

W–127 (21,600±1,000)
Pickaway Co., Harrisburg
Route US 62 cut
¼ mi. S of Harrisburg

(6′	*soil* shallow Miami A, B, C in region)
15′	*till*, gray with sand lenses, *wood* at base
(5′±	*gravel*)

W–88 (21,400±600)
Licking Co., Newark
Ramp Crk. at NYCRR
Kaiser Aluminum Corp.
¼ mi. W of Ohio 79

5–15′	*sand-gravel*, outwash fan of Ramp Crk.
60′+	*till*, dark gray, sticky twigs and *logs* at 45–60′ film of marcasite in cracks.
(200′±	more *till* on bedrock in old Newark Valley, wells nearby)

Four other sites involve wood in thick till lying on a buried soil or vegetation mat. The Sidney railroad cut log (W-188) is right on an excellent leached and clay-enriched soil where it probably grew. At Oxford (W-92), there are 6 inches of leached tan sands or reduced blue green lacustrine clays under a very thin layer (or layers) of leaves, twigs, insect wings, etc. At Kirkwood (W-414) and at Plum Point (W 177) the tills containing logs are traced to where they overlie older peat or gyttja over 32,000 and 37,000 years old. (Actually Dreimanis [1953, p. 1414] describes 2 tills separated by lacustrine clay, and logs are in the lower one, so the last advance was multiple or pulsating in the Erie Basin.) Thus, it seems most likely that the peat and soils are considerably older on the average than this last glaciation, and the ice merely picked up the last live trees to grow on that surface. Thus the underlying peat and soil is identical with that discussed already under "Early Wisconsin."

W–92 (19,980±500)
Butler Co., Oxford
Bull Run, ½ mi. W of US 27
NE¼ SW¼ Section 26

10′	*soil*, Miami A, B, C
25–60′	*till*, blue gray, compact silt or gravel lenses *logs* (over 100) from lower half
(½′	*soil*, leaf litter, twigs, bark, smear pale blue gray leached till)
(4′	*till*)
OR½′	*soil*, olive brown, with twigs leached 1–5″
1′	*sand* buff, calcareous, lenticular beds
OR 2–5′	*lacustrine* silts, laminated greenish gray, rotten smell
15′+	*shale*, Ordovician, calcareous

W–414 (22,000±1,000)
Shelby Co., Kirkwood
Brush Creek, ½ mi. E of US 25
NW¼ NW¼ Section 6

2′	*soil*, brown
(0–4½′	*gravel*, silty, alluvial shifting channel, inset into till near bridge)
2–25′	*till*, silty-clay rich local sand-silt lenses calcareous *logs* near base (W–414)
0–½′	*peat* band with twigs, discontinuous (W–415)
2–3′	*soil*, clay and sand blue black, ghosts of dolomite pebbles, grades to pH 6.5
0–3′	*gravel*, silty, reddish ghost dolomites, leached
1′+	*till*, silty-clay, calcareous

W–188 (23,000±800)
Shelby Co., Sidney
B&O RR cut, ¾ mi. W of US 25
SW¼ SE¼ Section 14

2′	*soil*, Miami shallow, A, B
5′	*till*, brown, clay rich
5′	*till*, pebbly, gray boulder pavement at base east-west fabric
0–2′	*fine sand*, well sorted, bedded
4′	*till*, clay-rich, brown, pH 7.4 containing silty pods (soil A zone) one *log* at very base
2–6′	*soil* leached 1½–4′, oxidized reddish, pH 6.4–6.6
30′	*till*, gray, compact north-south fabric containing 1′ silt lens 25′ down structureless 10 species gastropods mostly land pulmonate
W–177	see section for W–100 Plum Point

Finally, with this middle Wisconsin group of dates are four with different stratigraphy because they all occur in slightly higher hummocky belts mapped as end moraine. (W–71. This site is different also. These proglacial lake beds covered by till are described in White, [1953].) At Southern Hills (W–37) and at Westchester (W–304) the till bearing the wood is a continuous layer, compact, and blue gray, but above it are several lumps or lenses of other till, oxidized pale brown and interlayered with silty bedded gravels 10 to 40 feet deep. The lower till layer with wood is interpreted as plastered on beneath the last advancing ice; the overlying hodge-podge of till and poorly sorted gravels without wood is interpreted as a retreatal halt decades or centuries later. However, at Anderson Run (W–331) the masses of tangled wood lie between underlying compact silty gravels and overlying till. At Cuba (Y–448) on the outer Wisconsin moraine the few sticks come from 13 feet down in a surface excavation for a farm pond in till. In these two cases the ice last pushed over any earlier deposits of these end moraines.

W–304 (20,500±800)
Butler Co., Westchester
E. Fork Mill Crk.
NE¼ SW¼ Section 22
Skinner S & G Co.

3′	*soil*, A, B
40′	*outwash*, mound-like top, contorted beds coarse gravel to fine sand till masses to 15′ diameter
5′+	*till*, gray *logs* to 1′ in bank and creek

W–37 (20,700±600)
Montgomery Co., Southern Hills
Holes Creek bed

2–3′	*soil*, A, B, Miami
2–6′	*till*, brown
1′	*sand* lens
5′	*till* gray
3½′	*silt-fine sand*, laminated same layer ½ mi. away has fluvial molluscs
5′+	*till*, sticky blue gray *logs* in lower 2′ exposed

W–331 (17,980±400)
Ross Co., Anderson
Anderson Run cuts
1½ mi. S. of US 35

3′	*soil*, A, B
10–30′	*till*, mound-like top, dusty gray contorted lenses sand dipping sharply N *logs* to 1′, pods of needles in lower 3′
0–2′	*forest*, tangled logs, twigs, silt
5–15′	*sand-gravel*, silty, bedded, cross bedded, compact, part cemented, rusty streaks
(3′+	*bedrock* Devonian, Ohio shale in creek bed)

Y–448 (18,500±420)
Clinton Co., Cuba
Farris Rd., Whitson Farm
1.1 mi. SE of Cuba
S of Ohio 350

4′	*soil*, deep Miami, A, B 48″ leaching, gentle slope
8′	*till*, leached buff in C zone *logs* near base
2′+	*till*, gray with logs

Advance of the glacier.—When these Wisconsin C^{14} dates are plotted on the map of Ohio (fig. 1), it becomes evident that they form a consistent sequence from old at the north to young in the south. As the first C^{14} dates began coming in one hesitated to jump to this conclusion in view of the several potential errors in the radiocarbon method (such as the assumption that C^{14} content of trees 20,000 years ago was the same as that today). Each new date fitted the picture until the sequence seems firm beyond probable limits of laboratory error. Even if absolute dates are assumed incorrect, we must conclude that these dates show the gradual spread of the last ice southward. This leads to two conclusions contrary to traditional thinking: (1) The till sheets of the ground moraine in western Ohio are deposited in the main by *advancing* ice, (not retreating ice). (2) Between 24,600 and 16,600 years ago the retreats in Ohio, if there were any, were short-lived. The biggest gap in chronological record is between the Lake Erie region 24,600 years ago and Central Ohio 23,000 years ago; this may well involve ice edge pulsations, but such advances did not reach Shelby and Franklin counties where trees grew until 22,000 and 23,000 years ago.

The rate of average advance may be calculated in round figures. Only the average of many figures covers time span sufficient to disregard the probable error, but each individual segment between pairs of C^{14} dates has been figured to arrive at the most reliable average. Only dates in the same ice lobe have been compared and distances were measured along the line of average ice flow, which is fairly well known from striae, grooves, crag-and-tail, some 500 stone counts in till, and a few fabric measurements.

Area	*C^{14} dates used*	*Distance ice advanced in miles*	*Average rate in feet per year*
Upper Scioto lobe	W–71 to W–88, 127, Y–449	137–142 mi.	310
Upper Miami lobe	W–71 to W–188, 414	146	390
Lower Scioto lobe	Y–449 to W–91, 331, Y–448 &	40–54	
	W–127 to the same	29–47	53
Lower Miami lobe	W–188 to W–37, 92, 304,	38–58	
	Y–450 and W–414 to the same	37–58	108

Disregarding unknown but possible short retreats falling in the C^{14} time gaps, the overall rate was an average advance of 350 feet per year through northern Ohio and 83 feet per year in the southwestern quarter of Ohio. Individual values ranged from 223 to 481 feet per year in northern Ohio and 41 to 204 in southwestern Ohio. The average rate in southwestern Ohio is influenced strongly by the low age determination for Y–450 which may simply represent one of the oscillations of the ice near its maximum between 20,500 and 16,600 years ago. These oscillations correspond in C^{14} time scale to the Bloomington Moraine and other later moraines in Illinois.

LATE WISCONSIN FORESTS

C^{14} Date	*Number*	*County*	*Village*	*Landmark*	*Collector*
14,300±450	W–198	Williams	Edon	Ohio Turnpike	Rubin
12,380±370	W–57	Steuben, Ind.	Fremont		Wayne
13,020±400	W–65	" "	"		Wayne
12,600±600	M–350	" "	"		Zumberge
13,600±500	W–33	Cuyahoga	Cleveland	Canal S & G Co.	White
12,920±400	W–430	Erie	Pakertown	Turnpike at Rt. 4	Forysth
12,800±250	Y–240	Sandusky	Bellvue	NW¼ Sec. 10	Campbell 1953
(8,420±400	M–66	Madison	W. Jefferson	Orleton Farms	Baby)
(8,460±400	"	"	"	" "	")
9,600±500	"	"	"	" "	"
8,513±500	C–526	Erie	Castalia	Medusa Cem. pit	Goldthwait

(Those dates in parentheses are considered less reliable.)

Surface deposits.—Two of these "young" dates come from deposits associated with the Wabash Moraine. They lie on top of all till involved in the moraine and so post-date the last ice there. At Fremont in Steuben Co., Indiana (W–57, 65, M–350), the material is peat almost directly on the upper till. Is this sandy calcareous gravel overlying it deposited by meltwater from ice? Many geological visitors agree that it is glacial gravel, but that it may be redeposited in this swale-lowland situation cannot be denied. Therefore, it represents the minimum date for ice at Wabash Moraine, but it is likely it formed soon after the ice since it is at the base of several post-glacial layers. In the second case, Edon (W–198), the problem is similar. The wood is in lacustrine silts on high topography on top of the moraine. The silts are local, suggesting a small pool in an ice block hole. Thus, the readvance to Wabash Moraine dates from about 15,000 years ago, or, in any case, more than 14,300. This may well correspond to Cary substage or a part of what is now called Cary in Illinois.

W–57, W–65, M–350 (12,380 to 13,020)
Indiana, Steuben Co.
Fremont
NE¼ NE¼ Section 2

1′	*muck*, gray black
or	
(3½′	*clay*)
2′	*sandy gravel*, brown top leached, ghost pebbles
2′	*sand*, calcareous, brown clay seen at base
½′	*peat*, sandy matrix, *wood*
(¾′	*marl* in places)
2′	*till*, gray, calcareous, few small pebbles

W–198 (14,300±450)
Williams Co., Columbia or Edon
Ohio Turnpike and Rt. 49
NW¼ NW¼ Section 3

3′	*soil*, brown, C zone, in silt
3′	*silt*, stratified
½′	*silt-clay* with *wood* fragments
3′	*silt-fine sand*, interbedded laminae
8–15′	*till*, gray, clay-rich
½–1½′	*clay*, plastic, gray
3′	*sand*, gray

Three very closely spaced dates come from samples under well-established Lake Whittlesey deposits. Beneath each sample is till, probably the clay-rich till of a "late Cary" advance, (Winslow, White, and Webber, 1953, pp. 38–41). At Cleveland, near the Cuyahoga River (W–33), the sample lies right on the till at 690 feet elevation, well below the Whittlesey level. This represents the water rise at the end of Lake Arkona recorded here by 10 feet of overlying sandy silts. Its date is so old (13,600±500) as to crowd the intervening events after Wabash Moraine; did the deposition of Ft. Wayne Moraine, Defiance Moraine, and 3 stages of Lake Maumee take only 1,400 years? The Bellevue sample (Y–240), from a well, was simply in the higher beach sand—driftwood at the 735 foot lake level. Parkertown (W–430) is an intricate series of clay, sand, and humus layers right on the last till but underlying a good shingle beach of Lake Whittlesey (elevation 710 feet). These agree very well that Lake Whittlesey existed about 13,000 years ago.

One lake-controlled specimen falls at a much later date. It comes from the famous Castalia marshes (C–526) in a lower forest layer now explored over hundreds of acres (Dashnowski, 1912; Campbell, 1955). This is the only C^{14} site where the stumps are clearly rooted in place, so the underlying poorly laminated clays represent the higher (above 630 feet) glacial lake stages ending with Lake Warren (II?). Sands on those clays may represent slow dropping of the shore. Then the trees grew, probably during Lake Lundy time when ice still blocked the St. Lawrence River, but the edge was far away in New York and well up in Ontario. Calcareous shallow pools began to cover things up with marl, and travertine marshes alternated with periods of forest.

W–430 (12,920±400)
Erie Co., Parkertown
Ohio Turnpike at Ohio 4
NW¼ SE¼ Section 2

4½′	*gravel*, beach shingle
3′	*sand*, brown above, mottled below, calcareous
1′	*clay*, laminated, plastic, gray, *wood*, needles, cones at base
1′	*humus*, brown, sandy, noncalcareous
1½′	*sand*, gray, calcareous gravel at top
1½′	*clay*, gray, plastic
2½′	*till*, gray, stony
10′+	*limestone*

C–526 (8,513±500)
Erie Co., Castalia
Medusa Cement pit, Ohio 299
SW¼ SE¼ Section 3

1½′	*soil*, muck, gray
1½–4′	*marl*, gray to buff molluscs thin black peat beds (2–6″)
1–2′	*travertine*, lumpy, buff
½–1′	*marl*, gray black peat layers to 3″
1–2½′	*travertine*, lumpy plant casts, molluscs, logs at base
¼–1′	*forest* bed, logs to 2′ stumps in place, middle noncalcareous
1–3½′	*sand*, blue gray, sharp
(48′	*clay*, plastic, drilled by Ohio Geological Survey)

The final date (W. Jefferson, M–66) is typical of many kettle holes and ponds in west central Ohio. This is the only one studied in detail recently (Goldthwait, 1952; Sears and Clisby, 1952), so it is the only one dated. Like most others, it shows that an early period of open shallow pool (marl on the till) ended about 9,600 years ago when postglacial forests encroached and swamp vegetation became dense. As dated in other states, these were the declining days of the last (Valders, post Alleröd) ice advance.

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WISCONSIN AGE FORESTS IN WESTERN OHIO
II. VEGETATION AND BURIAL CONDITIONS

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INTRODUCTION

Much of what is known of Wisconsin vegetational history has come through study of bog deposits and, although wood fragments have been found rather widely in space and time, little concerted effort has been made to utilize them in interpreting the vegetation, climate and glacial history of the period. In the studies here reported, Wisconsin forest remains of three distinct time periods (ranging from 8,500 to more than 40,000 years ago) were investigated from 14 localities in Ohio and one in Indiana in order to determine the nature and fate of the forest cover, and to relate the rate of periglacial tree growth to probable speed of ice advance.

METHODS

Procedures followed were quite simple. In the case of logs, entire specimens, or portions of larger ones, were dug from the banks of streams, quarries, or cuts, bagged and numbered in the field, with a complete stratigraphic record kept by Dr. Goldthwait. Where cones, needles, etc. were found, samples of the encompassing material (till, etc.) were collected to be carefully washed apart in the laboratory. Identification of the woods to genus by their microscopic anatomy involved merely sectioning in the cross, radial, and tangential planes, generally with razor blade, occasionally by sliding microtome, and staining on the slide in dilute alcoholic safranin (1% in 50% ethanol). (It is not ordinarily possible to distinguish species on anatomical bases alone, although in some cases subgeneric groups can be differentiated, e.g., white- and red-oak groups, soft and hard maples, etc.) Examination was made at 150x and 645x.

Annual ring widths were measured with ocular micrometer, generally in radial section at a magnification of 100x, but occasionally in cross-section at 10x.

OLDEST FORESTS

Identifications were made from all of the Ohio locations having radiocarbon dates of more than 32,000 years which are reported in Part I. These are summarized in table 1. Inasmuch as these specimens are all old enough to make C^{14} determinations only very approximate, an exact sequence of vegetation, and hence of climates, is difficult to work out with certainty. With present evidence, it is clear only that both cold- and mild-climate forests occurred more than 32,000 years ago, but whether one followed the other or whether both existed more or less simultaneously in different parts of the state cannot yet be determined. For example, at two locations, Kirkwood (W-415) and Gahanna (W-263), both reported as "more than 37,000 years," only *Picea* (spruce) has been found, representing the same kind of cold-climate evergreen forest which was to be so widespread in Ohio near the ice perhaps 10,000 or 20,000 years later. On the other hand, the remaining two localities, Northampton (W-152) and Germantown (W-96), reported as "more than 40,000 years" and "more than 34,000 years," respectively (i.e., seemingly the *oldest* and the *youngest* of this particular age group), consist only of Angiosperms (table 1). Together with the reports of Orton (Part I, p. 211), a mild period of unknown duration more than 34,000 years ago is indicated for the southwestern quarter of Ohio.

Identified material from Kirkwood (W–415), Germantown (W–96), and Gahanna (W–263) is either a part of the dated sample itself, or, if not, it is so compressed, contorted and/or mineralized that correlation with dated samples is certain. In the case of the Northampton (W–152) material, the original specimen was sent in for radiocarbon determination before the writer's association with the project, hence no personal examination of it could be made. However, Dr. W. L. Stern of the Yale School of Forestry, in personal communication by Dr. R. F. Flint of the Yale Geochronometric Laboratory to Dr. Goldthwait, reports that the original W–152 specimen is either *Robinia* (black locust) or *Maclura* (osage orange), two genera whose wood can be distinguished only chemically. This identification, together with the others which were made by the writer and which are reported in table 1 for the Northampton site, indicate the same kind of mild period as is suggested by the Germantown (W–96) specimen of oak. Since it is possible to date these two sites only as "more than 40,000 years" (Northampton) and as "more than 34,000 years" (Germantown), it cannot be established at present whether or not they represent a single mild-climate period, although that is, of course, the simpler explanation.

TABLE 1

Localities and identifications for specimens greater than 34,000 years old

Locality	County	Woods				
		Picea	*Quercus*	*Fraxinus*	*Fagus*	Other*
Northampton (W–152)	Clark		1	2	2	1*
Kirkwood (W–415)	Shelby	3				
Germantown (W–96)	Montgomery		1			
Gahanna (W–263)	Franklin	1				

Figures for genera represent number of specimens. Radiocarbon laboratory numbers are given in parentheses in column one.

*This is the original specimen on which the radiocarbon age determination was made, and was not seen by the writer. It was identified by Dr. W. L. Stern of the Yale School of Forestry as "either *Robinia* (black locust) or *Maclura* (osage orange)."

FORESTS OF INTERMEDIATE AGE

Forest type.—Collections and identifications of plant material approximately 16,600 to 23,000 years old (see p. 213) were made from eight of the Ohio localities discussed in Part I. These are listed in table 2. The Cuba (Y–448, Clinton County) specimen, which was identified but not collected by the writer, is from a farm pond excavation on the outermost slope of the (terminal) moraine; all the remaining localities are stream cuts where many logs, some to more than a foot in diameter, are readily visible, protruding from the steep banks (fig. 1). There were no stumps in place, but a few specimens resembled uprooted stumps.

Being embedded *in* till (Part I), it is apparent that these represent forests invaded by the glacier. The appearance and condition of much of the wood strongly suggests that the trees were actually alive and growing, although more and more slowly, as the ice gradually overrode them. For example, in many specimens the bark is bruised but tightly adherent to the wood, whereas, had the trees been dead when overridden, the bark should have been shed entirely. Bent and broken specimens are irregularly splintered at the break, not cleanly snapped as is true of dead wood. Moreover, many specimens from five separate localities in Butler and Ross Counties (Oxford W–92, Darrtown Y–450, Westchester W–304, Anderson Run W–331, and Biers Run W–91) show marked decrease in growth ring size

during the last years of growth. The significance of this as regards rate of ice advance is discussed below. All of these facts to us clearly indicate movement of the ice into living forests, much as photographed by Lawrence (1950) along Taku Glacier in Alaska.

The remarkable preservation of bark and stubs of branches as well as the absence of well-worn, rounded or gouged surfaces all indicate only short transport of these logs by the ice and suggest that they could hardly have been moved over half a mile from their original growth sites. This conclusion is further borne out by the occurrence of specimens in large groups in nearly every case.

FIGURE 1. Stream cut at Biers Run, Ross County, Ohio (W-91), showing typical collecting locality with logs protruding from banks. These specimens are all *Picea* (spruce).

As shown in table 2, of the 180 specimens of wood of intermediate age which were examined, 176 are spruce (*Picea*). In addition, four collections of needles of white spruce (*P. glauca*) were made. Wright (1920, pp. 598-600) refers to "red cedar" logs observed at Darrtown (Y-450), but there is no indication that this was more than a passing macroscopic judgment. Although several of the specimens obtained at this location in the present study were dark reddish-brown in color, their microscopic anatomy is clearly that of spruce.

The occurrence of such a single strong dominant species is not surprising for, although in the northern evergreen forest today, spruce is commonly associated in bogs with tamarack (*Larix laricina*) and, on upland areas, with fir (*Abies balsamea*), Heusser (1952, 1954) and others find periods of spruce dominance in their Alaskan studies. Sears (1930, 1948) and Potzger (1951) also record the existence of a considerable period of forest with spruce as the single dominant

(sometimes comprising 100% of the pollen count) in their bog studies in northern Ohio and along the Wisconsin boundary in various parts of eastern United States. Rosendahl (1948) concludes, "A heavy preponderance of white spruce in the Pleistocene forests of Minnesota is evidenced not alone by its nearly universal occurrence but also by the great amount of spruce wood recovered from many of the sites. . . . Wherever wood of other species has been found, it is always in very minor quantity compared with spruce."

The picture which emerges for southern and southwestern Ohio when the ice arrived in the area 16,600 to 23,000 years ago, is one of cool climate, but which was becoming gradually cooler and moister and, close to the ice, almost subarctic, supporting on areas of glacial outwash a coniferous forest probably relatively narrow in width and composed largely of spruce (in the main white spruce, *Picea glauca*). (For example, Braun (1951), in discussing refugia of the deciduous forest during the Wisconsin, concludes that, with depression of altitudinal forest zones south of the ice, "this would bring the deciduous forest zone to the plateau level about 50 miles south of the ice.") That at least scattered acid swampy areas of tamarack (*Larix laricina*) also occurred is suggested by three collections of this

TABLE 2

Localities and identification summary for specimens of 16,600 to 27,500 year-old age group

Locality	County	Woods			Needles
		Picea	Larix	Thuja	Picea glauca
Brush Creek (W–414)	Shelby	2			
Holes Creek (W–37)	Montgomery	1			
Westchester (W–304)	Butler	18			1
Darrtown (Y–450)	Butler	20			
Oxford (W–92)	Butler	24			
Biers Run (W–91)	Ross	67	1		
Anderson Run (W–331)	Ross	43	2	1	3
Cuba (Y–448)	Clinton	1			

For woods, figures represent number of *specimens:* for needles, number of *samples* containing needles is listed. Radiocarbon laboratory numbers are given in parentheses in column one.

species in Ross County (table 2). Undoubtedly some of the spruce wood from Anderson Run (W–331) and Biers Run (W–91), then, is black spruce (*Picea mariana*) although all three of the needle collections (Anderson Run, W–331) are white spruce. The single specimen of white cedar (*Thuja occidentalis*) from Anderson Run (W–331) indicates the occasional presence of this species, either along rocky banks of meltwater streams flowing from slowly advancing or fluctuating ice somewhere to the north or, less likely, in occasional calcareous swamps. *Picea* does not now occur natively in Ohio; *Larix* occurs in the northeastern counties of Portage and Stark, and *Thuja* is found only locally in the southwestern quarter of the state (Adams, Green and Champaign Counties). Such forests now exist widely in Alaska, Canada and Labrador, extending south into the United States in Minnesota, Wisconsin, Michigan, and New England.

Annual rings and rate of ice advance.—Perhaps the best evidence for feeling that we are dealing here with living forests overwhelmed by advancing ice is the marked and progressive decrease in annual growth ring width noted in many specimens from Butler and Ross Counties, the southernmost of this study. Only logs in which the presence of attached bark indicates that record of the complete life span of the tree is preserved are considered here. This decline in ring width

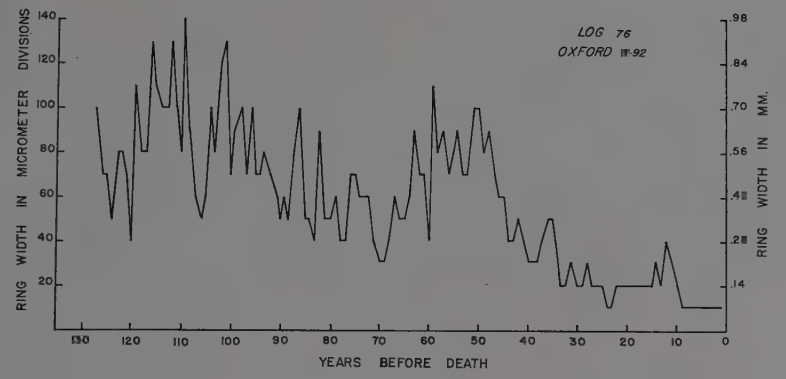
extended generally over the last 50 to 100 years of life of individual trees, and reflects a gradual deterioration in growing conditions ostensibly due to ice approach. Rosendahl (1948) found the same condition (over the last 20 rings) in spruce of early Wisconsin in Minnesota, as did Mathews (1951) in southwestern British Columbia. Regarding this decrease in ring width, Mathews says, ". . . the retardation of growth may be attributed to the gradual approach of the glaciers, which seem to have been directly responsible for (the trees') untimely ends . . . this influence of the glacier on tree growth does not extend far beyond its front. . . ." Rosendahl (1948) comes to much the same conclusion. Many investigators have noted a marked responsiveness of spruce to temperature, the effect being chiefly through lower summer mean temperatures (Hare, 1950).

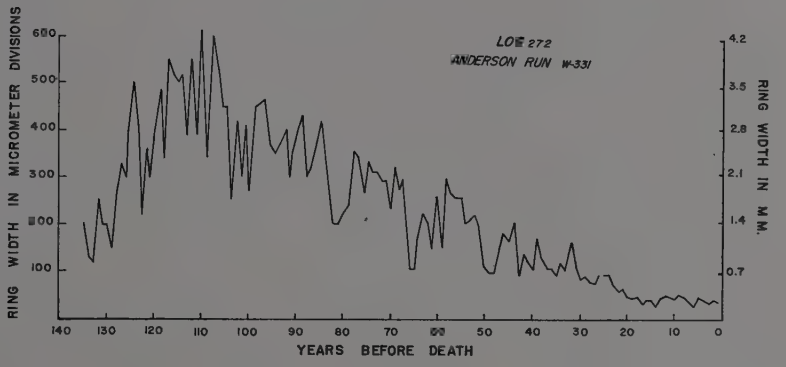
It does not seem plausible that these trees could have been drowned, either on grounds of stratigraphy or because of the length of time over which growth diminution occurred. Likewise, senescence can be eliminated since most of the logs were only 100 to 160 years old at death, whereas spruce has a usual life span of 250 years or more. Finally, the small diameter of many of these trees for their age suggests that they lived in a pretty rigorous climate.

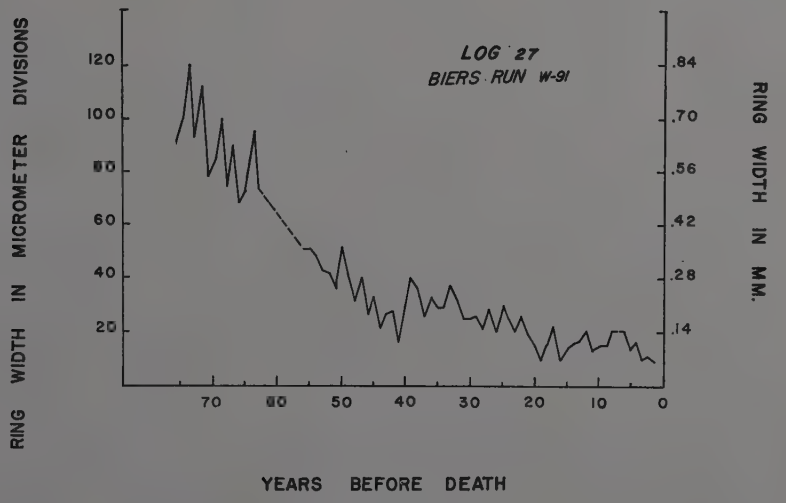
Ring measurements were made on material from all localities studied. Some of these are shown in graph form in figures 2 to 7. Note that Oxford (W–92), Anderson Run (W–331), Biers Run (W–91), and Darrtown (Y–450) are consistent with each other in showing a marked decrease in annual growth to have begun 50 to 97 years before death. A good bit of material for Westchester (W–304), because of mineralization, did not lend itself as readily to graphing since long blocks of consecutive rings could not be measured accurately. The single one represented in figure 7 indicates growth rate decrease to have occurred over the much longer period of about 160 years. This may not be typical for this locality, for Westchester log #230 (mineralized) does show a progressive decrease in ring width from 0.53 mm down to 0.16 mm in what is estimated to be the last 60 years of life. The outermost individual rings in this specimen were composed of one to a few rows of narrow cells, a situation similar to that which Rosendahl (1948) observed in his Minnesota Pleistocene material. The nature of the outermost rings here suggests that this tree spent its last years quite close to the ice where winter-summer temperature differences were slight and soil temperatures low. Another Westchester log, #224, shows a gradient of ring width from 1.82 mm down to 0.25 mm over about the last 80 rings. It is felt, therefore, that Westchester (W 304) material is generally consistent with the other Butler and Ross County locations.

The largest unknown factor in relating this decreased growth to the speed at which the ice was approaching is precise knowledge of the width of a sufficiently refrigerated zone, as to both air and ground water temperature, out ahead of the ice to produce such effects on the growth of (white) spruce. From the work of Mathews (1951) in British Columbia, it would appear that this zone is no wider than a half mile, and perhaps less.

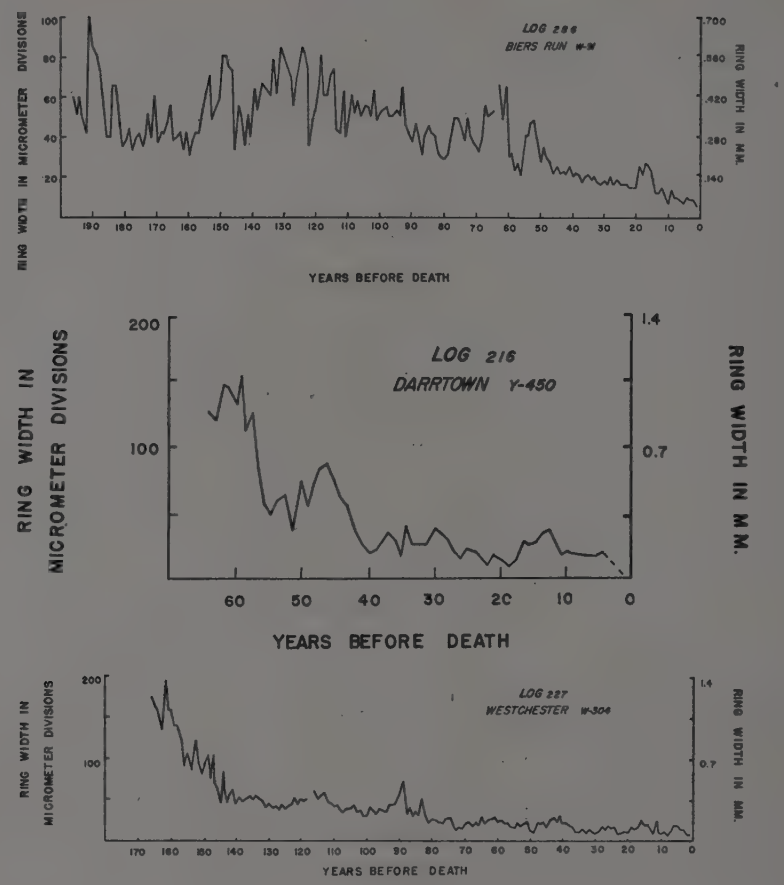
Using an average figure of 70 years for the period of marked growth diminution, and a half mile as the width of the effective zone of refrigeration, an average net advance of the ice of about 38 feet per year is arrived at for the Butler and Ross County localities. This is a little lower than, but quite compatible with, speeds calculated by Dr. Goldthwait from comparative radiocarbon dates along known lines of ice flow in southern Ohio (Part I) and actually suggests a verification of the estimate of one half mile as the width of the zone of refrigeration. The figure of approximately 38 feet per year, based on growth pattern, seems even more appropriate when it is remembered that the Oxford (W–92), Darrtown (Y–450), Westchester (W–304), Anderson Run (W 331), and Biers Run (W–91) sites lie only about 3 to 16 miles inside the limits of maximum southward ice advance. Just as the ice moved more rapidly southward in northern than in southern Ohio, so should it have been decelerating progressively still more as it neared its southern limit.


LOG 76
OXFORD W-92
RING WIDTH IN MICROMETER DIVISIONS
RING WIDTH IN M.M.
YEARS BEFORE DEATH


LOG 272
ANDERSON RUN W-331
RING WIDTH IN MICROMETER DIVISIONS
RING WIDTH IN M.M.
YEARS BEFORE DEATH


LOG 27
BIERS RUN W-91
RING WIDTH IN MICROMETER DIVISIONS
RING WIDTH IN M.M.
YEARS BEFORE DEATH

FIGURES 2–4



FIGURES 5–7

Whereas, then, comparative C^{14} dates tell a great deal about rate of advance over fairly long distances, study of tree growth rings permits a detailed interpolation of average rates of advance or retreat over very small distances as well as a measurement of small fluctuations over periods of time reckoned in decades or less. In other words, by the two complementary approaches of comparative dating and ring measurements, it should be possible to reach a fairly clear picture of both major and minor perturbations in the ice front wherever suitable material, ancient or living, is available.

YOUNGEST FORESTS

Collections were made at three of the "young" sites reported in Part I of this paper. These, and the nature and identification of the material at each, are shown in table 3.

Materials from Erie County, Ohio, (Parkertown, W-430) and Steuben County,

Indiana, (W–65) show C^{14} dates of close to 13,000 years (pp. 217–18, whereas other radiocarbon evidence indicates that the ice, in its southward advance must have passed through this part of the country about 24,000 years ago. It is therefore clear that forests at these two localities, although again spruce in the main, must have developed *after retreat* and were not buried under the same conditions as those in southern Ohio. Stratigraphy (pp. 217–18) also indicates this.

Because of the predominance of spruce and the presence of other boreal species, it is evident that the climate, at least at the time of their establishment, was cold, much like that of periglacial southern Ohio some 7,000 years earlier. The association is either spruce-fir or spruce giving way to spruce-fir, but with admixture of hemlock. Hemlock, which today extends farther south than either spruce or fir, is still found locally even in southern Ohio. In Pleistocene collections it is indicative of a moist and cool, but probably warming climate. No evidence suggesting periglacial tundra was found.

TABLE 3

Localities and identification summary for specimens of 8,500 to 14,000 year-old group

Locality	County	Woods												Needles				Cones		Seeds
		Picea	Abies	Tsuga	Fraxinus	Acer	Cornus	Juniperus	Carya	Populus	Quercus	Carpinus	Ulmus	Picea glauca	Picea mariana	Abies balsamea	Tsuga canadensis	Picea glauca	Picea mariana	Picea
Parkertown (W–430)	Erie	25	2	2										1	2	1	2	1	1	
Indiana (W–65)	Steuben	8												2	2			1		2
Castalia (C–526)	Erie				16	9	1	2	2	2	1	1	1							

For woods, cones and seeds, figures represent number of *specimens:* for needles, number of *samples* containing needes is listed. Radiocarbon laboratory numbers are given in parentheses in column one.

Whereas the forests in southern Ohio were killed in being overridden by advancing ice, a similar end cannot have come to these northern forests. The stratigraphy (pp. 217–18) suggests drowning as the likely cause. This conclusion also appears to be borne out by the annual growth of the trees, many of which perished in the short space of less than a decade, as compared with a progressive slowing of growth over nearly a century in southern Ohio forests. Presumably, by the time glacial lakes had lowered again and new forest growth could succeed the drowned cold-climate evergreen association, sufficient warming had taken place to permit entry of modern broad-leaved angiosperm forests, though this is merely surmised at present.

The Castalia, Ohio (C–526), collection represents an entirely different situation from the Parkertown or Indiana forests. Specifically, the Castalia woods are about 4,500 years younger, they are almost entirely composed of Angiosperms, and they grew under very different physiographic and climatic conditions.

In order to evaluate these specimens properly, some explanation of present and past conditions in this part of northern Ohio is necessary. Climax forest today there generally is beech-maple, westward giving way to patches of prairie, especially on old glacial lake beds, with many wet areas having a characteristic

succession culminating in a distinctive elm-ash-soft maple swamp community. This latter is reported to occupy much of the area within the old beach lines of Lakes Maumee, Whittlesey, and Warren according to Sampson (1930) who says, "The composition of the swamp forest is dependent in part upon previous vegetational history. The physiographic sites in which the swamp forest of northern Ohio has developed are old lake beds, floodplains, and pre-erosion post-glacial flats. . . . On certain pre-erosion post-glacial flats the deciduous swamp forest communities undoubtedly succeeded forest communities of the northern evergreen forest, such as spruce, balsam, arbor-vitae, birch, and probably hemlock and white pine during the later post-glacial migration."

Characteristic species of this forest community, according to Sampson (1930) are: cottonwood (*Populus deltoides*), black ash (*Fraxinus nigra*), silver maple (*Acer saccharinum*), red maple (*Acer rubrum*), yellow birch (*Betula lutea*), American elm (*Ulmus americana*), sour gum (*Nyssa sylvatica*), and swamp white oak (*Quercus*

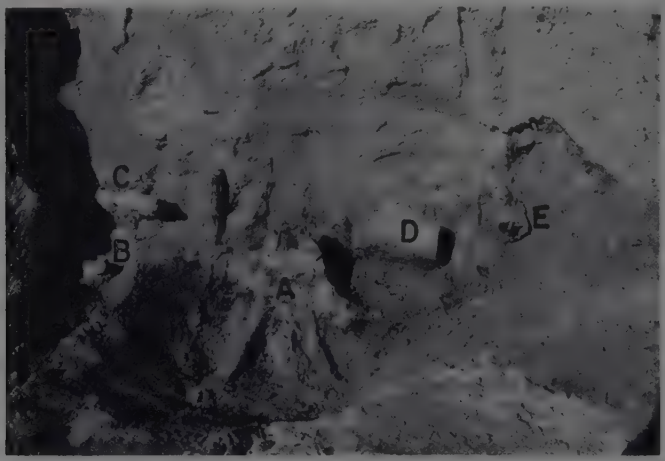


FIGURE 8. Buried stump (A) in place at Castalia, Erie County, Ohio (C–526). This specimen is *Fraxinus* (ash) and measured 10 inches in diameter. Note horizontal logs at B, C, D, and E.

bicolor). The list of genera reported here for the Castalia collection is nearly identical: *Fraxinus*, *Acer*, *Populus*, *Ulmus*, and *Quercus*. Sampson (1930) notes that in certain successional stages from the swamp forest, the following species occur as drainage improves: white ash (*Fraxinus americana*), blue beech (*Carpinus caroliniana*), several species of hickory (*Carya*), oaks (*Quercus*), red elm (*Ulmus fulva*), dogwood (*Cornus florida*), basswood (*Tilia americana*), buckeye (*Aesculus glabra*), black cherry (*Prunus serotina*), beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), etc. Of these, ash, blue beech, hickory, and dogwood have been identified in the current Castalia collection. The similarity of ancient and modern forests strongly suggests closely parallel climatic and ground-water conditions.

The area where the specimens here reported on were collected is being strip mined for marl, leaving pits some 6 feet deep. In these pits two distinct forest layers may be seen. The upper lies from 2 to 4 feet below the original surface (i.e., before mining operations) and is composed of alternating black layers and gray marl, with many twigs, small logs, and much reedy material. Some $2\frac{1}{2}$ to 4 feet below, lies a 6-inch-thick lower forest layer. See stratigraphy, p. 218.

Genera represented in the upper and lower forest layers are alike except for the occurrence of red cedar (*Juniperus virginiana*) in the latter. Whereas the upper layer consists of small to medium fragments (a few 6 inch logs) lying more or less horizontally, the lower layer contains medium to large logs (up to 12 inches in diameter) and several stumps which were clearly buried in place (fig. 8).

From a consideration of the genera represented in the Castalia collection, the vegetational makeup of the modern swamp forest community of northern Ohio, and what is known of the postglacial Lake Erie history, it must be assumed that the lower forest zone, at least, represents a community growing under conditions of rather high ground water, probably not far from the open lake, in a relatively mild climate not substantially different from that of the present time. Except for red cedar, it would be difficult to differentiate this forest of 8,500 years ago from others now living in northern Ohio. Then, as thick deposits of sandy marl were laid down in shallow, limy pools, this lower forest was drowned. Later—after an apparently fairly long interval because of the depth of material overlying the lower forest—surface drainage conditions improved somewhat, and there was a recurrence of a typical swamp forest formation.

SUMMARY

1. Spruce (*Picea*) logs, radiocarbon age "more than 37,000 years," from central Ohio indicate the same kind of cool-moist forest known to have existed later near the ice in the same region. On the other hand, two southwestern Ohio groups of Angiosperm remains, including oak (*Quercus*), ash (*Fraxinus*) and beech (*Fagus*), "more than 34,000" and "more than 40,000 years" in age, indicate warm conditions of unknown duration over 34,000 years ago for that region. There is no evidence that more than one such warm period is involved.

2. During the period 16,600 to 23,000 years ago, in southern and southwestern Ohio, there were extensive, though probably narrow, belts of evergreen forests with spruce (*Picea*) as the strong dominant. Tamarack (*Larix*) and white cedar (*Thuja*) were also present in small number. Remains examined included wood and needles.

3. These 16,600 to 23,000 year old forests were invaded by advancing ice and buried after only short transport. Study of their annual ring suggest an *average* speed of ice advance near its maximum southern limit of about 38 feet per year. Applications to problems of advance or retreat over very small distances are suggested.

4. Evidence is presented indicating early entry of a spruce or spruce-fir association in the wake of retreating ice in northern Ohio about 13,000 years ago, with no evidence of a tundra zone. Wood, needles, cones, and seeds were collected and studied. Drowning of these forests is evident, and their succession by broad-leaved formations as climate ameliorated is suggested.

5. Northern Ohio forests, and therefore climatic influences, by 8,500 years ago appear similar to those of the present.

ACKNOWLEDGMENTS

I wish to express grateful appreciation to Dr. Richard P. Goldthwait of The Ohio State University Geology Department for his congenial and inspirational field companionship, and for having invited my participation in this study. Special thanks are due also to the personnel of the Water Division of the Ohio Department of Natural Resources, which financed the project.

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Conservation Education in American Colleges. *Charles E. Lively* and *Jack J. Preiss*. The Ronald Press Company, New York. 1957. ix+267 pp.

A number of the readers of this Journal have made contributions to this detailed survey of conservation education in American Colleges by returning questionnaires. Charles E. Lively and Jack Preiss made this survey of 1,496 colleges and universities with financial assistance from the Conservation Foundation.

Questionnaires were answered by a total of 1,024 schools, and of these 55.3 percent were teaching some conservation. Teachers colleges outshone all except the land grant universities; 89.2 per cent of the former taught conservation while 94 percent of the land-grant universities did. Regionally, the Mountain states led with a 73 percent score while the North Central concentration of institutions rated third, with 64 percent teaching some conservation. Only one half of the "liberal arts" colleges teach conservation, but the fraction was less for schools with some religious affiliation. Earlier studies showed geography to be the commonest area for conservation courses, but geography has now slipped to third rank while natural science now leads.

The specific comparisons made by these two statistically-minded investigators cover 210 out of 267 pages, and they are tedious reading. However, the book ends with a few conclusions and some helpful recommendations. A person interested in comparing conservation education of his institution with some general characteristics of others or who wants a good estimate of the status of conservation education in American colleges about 1955 can spend many interesting hours with this compilation.

CARL S. JOHNSON

Eels, Leon Bertin. 2nd Ed., revised and enlarged by *Maurice Burton*, and translated from the French by Betty Roquerbe. Philosophical Library, New York. vi+192 pp. $7.50.

This detailed report on the eels of the world, with emphasis on the European eel, summarizes the studies of many scientists. It brings the known facts of the amazing life-history of the eel down to date, listing chronologically the discoveries of the Danish scientist, Johannes Schmidt, and adding the subsequent discoveries of students of Schmidt. Briefly, the European eel life history exhibits eight phases, listed as follows: (1) Birth in the Sargasso Sea and existence as a transparent leptocephalus. (2) Migration under the influence of ocean currents towards the Continental waters. (3) Metamorphosis of the leptocephali into minute transparent "elvers." (4) Invasion by the elvers of the Continental fresh waters. (5) Metamorphosis of the elvers into yellow eels. (6) Growth of the yellow eels in rivers and lakes. (7) Final metamorphosis into silver eels, and the development of male or female sexual maturity. (8) Migration of the silver eels downstream out of fresh water into the ocean and to the Sargasso Sea where they breed and die.

There are chapters devoted to each phase of the European eel life history, and there are chapters allocated to discussion of the eel's adaptability to variations in salinity, of the toxicity of the eel's blood serum, of the phenomenon of juvenile hermaphroditism.

This book should be in the library of every student of fishes, and of many physiologists. It is also good reading for the layman.

THOMAS H. LANGLOIS

ECOLOGICAL NOTES ON THE PINE MIDGES *RETINODIPLOSIS RESINICOLA* (OSTEN SACKEN) AND *R. INOPIS* (OSTEN SACKEN) IN SOUTHERN OHIO

(DIPTERA, ITONIDIDAE)

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The midges *Retinodiplosis resinicola* (Osten Sacken) and *R. inopis* (Osten Sacken) develop in masses of resin on pine twigs (fig. 1) in aggregations of several individuals to a mass. Occasionally their feeding becomes of economic importance (Barnes, 1951). The two species were studied in southern Ohio mainly in the Shawnee State Forest during three growing seasons from 1951 through 1953.

Midge adults in this study were identified by R. H. Foote of the Insect Identification and Parasite Introduction Section, U. S. Department of Agriculture. Parasites were identified by specialists of the same section as follows: Pteromalidae and Eupelmidae, B. D. Burks; Platygasteridae, C. F. W. Muesebeck.

INCIDENCE

Retinodiplosis spp. adults were reared or their larvae were seen developing at several widely scattered localities in southern Ohio. These insects probably occur throughout the ranges of their host pines in Ohio. Authentically identified specimens of *R. resinicola* and *R. inopis* were reared from pitch pine, *Pinus rigida* Miller, and specimens of *R. inopis* were reared from Virginia pine, *Pinus virginiana* Miller. These determinations were made with male specimens because females of the two species cannot be reliably differentiated (Barnes, 1951). Sample specimens sent to the identifier proved to be mainly females. Both midges occurred in the same pine stands, but *R. inopis* was less abundant than *R. resinicola*.

At a time when developing maggots were abundant, aggregations were examined for size and age of that part of the host supporting them. Aggregations were found on pitch pine twigs, branches, and trunks up to 2 inches in diameter and up to 5 years old. Many more twigs than branches and more branches than trunks were infested. Pitch pine trees from 2 to approximately 12 feet in height were seen supporting dense maggot populations.

INJURY

Exactly what the maggots eat is still not clear. Barnes (1951) has reviewed the available information on this subject. Infestation causes swellings and distortions on young twigs (fig. 1, 2, 3) and probably a reduction in the vigor of the tree. Healed feeding places on older stems form resin pockets in the wood ("bird's-eye pine"). Twigs and even trees are said to be killed in severe infestations (Barnes, 1951), but no infested twigs in the Shawnee Forest died.

LIFE HISTORIES

Tracing the seasonal histories of the midges was difficult because of a marked decline in their abundance following emergence of the spring brood in May. The observations in table 1 suggest that approximately 4 broods a year are produced.

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The maximum number of broods per year may be greater; there is probably much overlapping of generations after May because of the long emergence period of the spring brood. The late summer and early spring observations (table 1) suggest that the winter is spent in the larval stage. Moreover, typical *Retinodiplosis* larval aggregations on pitch pine were seen during the winter in the vicinity of Washington, D. C. Other observers have also given the larval stage as the wintering form (Barnes, 1951).

Explanation of Figures 1–4

1. Resin masses of *Retinodiplosis* sp. probably *inopis* on pitch pine twigs. Needles were removed for the photograph.
2. Pitch pine twigs one year after deformation by *Retinodiplosis* sp. probably *inopis*. Needles were removed for the photograph.
3. Pitch pine twigs two years after deformation by *Retinodiplosis* sp. probably *inopis*.
4. Resinous cocoons of *Retinodiplosis inopis* on buds and needles of pitch pine.

The resin masses inhabited by *R. resinicola* frequently were larger, contained more individuals, and occurred on larger stems than the masses of *R. inopis*. *R. resinicola* masses were usually opalescent while *R. inopis* masses were often transparent. In 24 aggregations examined in the spring, the number of nearly or fully grown *Retinodiplosis* spp. larvae and pupae per aggregation varied from 2 to 29, with the mode being 5.

The larvae of *R. resinicola* pupated in silken cells spun within their resin masses. These cells protected the pupae from the sticky resin. Pupae were oriented with

their heads outward from the mass. Just before emergence of adults, the pupae worked themselves about half way out of their cells by manipulating their abdomens. Following adult emergence, the empty pupal skins protruded from resin masses.

In contrast to *R. resinicola*, the larvae of *R. inopis* crawled away from their resin masses and pupated in resinous cells elsewhere on the twig (fig. 4). Barnes (1951) mentioned the different pupating habits of the two species as diagnostic characters.

R. resinicola and *R. inopis* adults of the spring brood emerged concurrently in the insectary in May. Spring insectary emergence began in 1952 on May 4, and in 1953 on May 3. The flies issued over periods ranging from 24 to 38 days. Adults were short lived. Sixteen *R. resinicola* individuals which had emerged during the previous 24 hours were put in a battery jar. The following day, half of the midges in the jar were dead, and two days later, all but three were dead. There had also been placed in the jar a freshly cut pine twig and three microscope slides each containing a droplet of fresh resin. During the first 24 hours, the

TABLE 1

Seasonal history observations on Retinodiplosis *spp. in southern Ohio*

Date	Observation
April 2, 1953	Full grown larvae.
April 16	Partially grown larvae.
April 30	Full grown larvae.
May 7	Pupae
May 14	Pupae and full grown larvae.
May 28	Pupae and empty pupal cases.
June 19	Full grown larvae.
July 1, 1952	Pupae and empty pupal cases.
July 9, 1953	Full grown larvae.
July 30	Do.
September 3	Do.

confined midges laid several hundred eggs. The midges were attracted to the resin for oviposition, a fact well brought out earlier by Eckel (1903). Some of the eggs were laid in the resin on the slides, and many on the cut ends of the twig where resin had exuded; but most were laid on the walls of the jar where almost imperceptible traces of resin had been deposited accidentally in handling.

PARASITIZATION

Emergence records from randomly collected aggregations of both species of *Retinodiplosis* during the springs of 1952 and 1953 showed that 15 percent of the midges were parasitized. Listed in descending order of their abundance, the parasites (all hymenopterous) were *Systasis diplosidis* Eckel, *Habrocytus* sp., *Norbanus* sp. (Pteromalidae); *Platygaster diplosidis* (Ashmead) (Platygasteridae); and *Eupelmus* sp. (Eupelmidae). Definite associations of parasites with host species were noted for only two of the parasites: *Systasis diplosidis* on *Retinodiplosis resinicola* and *Platygaster diplosidis* on *Retinodiplosis inopis*. Eckel (1903) found *Systasis diplosidis*, a *Eupelmus* sp., and *Platygaster diplosidis* parasitizing *Retinodiplosis resinicola* in Massachusetts.

Systasis diplosidis accounted for about three-fourths of all parasitization. This parasite appeared in the insectary all three rearing years. It was solitary in its development and apparently did not affect all individuals in a host aggrega-

tion. Besides emerging in spring, it is known to have developed on at least one later host generation. Adults began issuing in spring during the last one-third to one-fourth of the host emergence period. Of 30 parasite specimens obtained from several maggot aggregations, 19 were males and 11 females.

Habrocytus sp. accounted for most of the remaining parasitization. This parasite emerged concurrently with *Systasis diplosidis*. Of 7 *Habrocytus* sp. individuals picked at random for identification, 3 were males and 4 females.

Two aggregations of *Platygaster diplosidis* issued in the insectary on May 11, 1953, through several round holes gnawed by the adults in their *Retinodiplosis inopis* cells. These aggregations numbered 9 and 10 adults. Before parasite emergence, the host cells looked black because of the dark color of the parasites inside them.

Two females of *Norbanus* sp. emerged on May 31, 1953, and one female of *Eupelmus* sp. on May 25, 1953.

ANNUAL POPULATION FLUCTUATION

For three years it was consistently observed that aggregations of developing *Retinodiplosis resinicola* midges were abundant in the spring, but scarce during the remainder of the growing season. This annual fluctuation correlates with availability of potential development sites, a factor which seems to be determined by the host growing schedule.

In southern Ohio, pitch pine undergoes its most rapid growth in early spring. At this time, twigs swell and many tiny lesions frequently form in the bark of young trees. Small amounts of resin exude from these lesions. Eckel (1903) showed that minute exudates are ideal for the establishment of young *R. resinicola* maggots. That the midges are attracted to such exudates for oviposition seems well established by Eckel's work and the insectary observations just described. Thus potential development sites are abundant early in the spring when the overwintering brood emerges and begins ovipositing. Consequently, the population level of the following generation soars. By the time members of this large brood are ready to oviposit, however, conditions have changed. Host growth is slower and earlier lesions have healed or the exudates have hardened. As a result, fewer potential development sites are available and population levels drop. The same fluctuation can be inferred from Eckel's paper on *R. resinicola* in Massachusetts. The extent to which this phenomenon occurs in *R. inopis* is not known.

An experiment was done to test the hypothesis that this annual fluctuation in the Shawnee Forest is due mainly to availability of potential development places. On July 9, 1953, a date when maggots were hard to find, roadside pitch pine saplings at two midge focal points were blazed liberally with a pocket knife. Three weeks later resin exudates from these blazes were examined, and many small aggregations of maggots were found. Not all of the exudates contained insects, but the results clearly supported the hypothesis.

A spatial rather than temporal rhythm in abundance of a western species of *Retinodiplosis* was correlated by Austin et al. (1945) with presence or absence of natural resin exudation from shoots of different ponderosa pine trees in the same stand. Trees whose shoots were viscid with resin exudation were heavily infested whereas those whose shoots were not viscid were lightly infested.

During the summers, when *R. resinicola* population levels in the Shawnee Forest were low, the midges were found developing mostly in resin exudates caused by other insects or by unknown agencies. Resin masses of previous midge generations were never found harboring new aggregations. Two insect species providing habitations in which midges were observed developing were the pitch pine tip moth, *Rhyacionia rigidana* (Fernald), and the Virginia pitch-nodule moth, *Petrova wenzeli* (Kearfott) (=*P. virginiana* (Busck)). Also, Comstock

(1880) noted that the maggots occurred in exudates associated with the pitch twig moth, *P. comstockiana* (Fernald).

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THE MOSCA (CHIBCHA)

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This paper is a reconstruction of the societal and material culture of the Mosca Indians as it was prior to the Spanish conquest. Mosca is the word for man in their language and was used by the first Spaniards to designate the subjects of Bogota and Tunja (Aguado, 1916). This group is especially interesting because it appears to have been in the process of forming a State as this term can be defined in modern times. According to Steward's recent definition (1949), it had attained all the prerequisites for a high civilization. These include intense agriculture, stratified social classes, and a priest-temple-idol cult. As we shall see the Moscas had, in many ways, advanced much farther on the road to statehood.

Mosca civilization is quite noticeably lacking in artifacts or constructions of durable material that leave important archaeological remains. It is, therefore, necessary to reconstruct as far as possible from the writings of some of the Spaniards who were eyewitnesses or who had access to eyewitness accounts, either written or verbal. Most of these accounts were not written on the spot but took the form of memoirs written by soldiers after retirement from active duty, or compilations by priests who wrote 1 to 3 generations after the conquest.

Aguado's account is fairly extensive and seems to be reliable though a little difficult to read. Castellanos (1886) writes in verse but gives quite detailed knowledge, probably the best of the available primary sources. The account of San Martin and Lebrija (1916) is short but gives a little additional knowledge and is valuable for the part devoted to the Panche Indians. The anonymous Epitome (1920) is apparently reliable and contains much new material. Piedrahita (1942), while a secondary source, worked from primary material and transcribed accurately and fairly completely. Piedrahita had access to the accounts of Gonzale Jimenez de Quesada who led the expedition to Bogota. This account has been lost but if Piedrahita covered it as well as he appears to have covered the work of Castellanos, then we have most of the contents of Quesada's writing.

Mosca territory is located on the plateau of Cundinamarca in Colombia. The exact location of boundaries and tribal divisions and a description of the climate is covered by Kroeber (1946) in volume 2 of the Handbook of South American Indians.

Subsistance

One of the main sources of food supply was maize. Plantings were made during eight months of the year assuring an almost continuous harvest (San Martin and Lebrija, 1916). Several kinds of potatoes were grown, among them white, yellow, and purple varieties (Piedrahita, 1942). Some manioc was raised (Aguado, 1916). Another root crop mentioned is turnips, another tuber, perhaps arracacha or tropaeolum (Aguado, 1916). Several varieties of beans were cultivated. Gourds provided vessels and utensils. There were some other unnamed seed crops. Agave and esparto grass provided fibers (Aguado, 1916). Peppers were grown extensively for flavoring. Chicha beer was made from ground grain (Castellanos, 1886). Coca was cultivated and entered heavily into their ceremonial and religious life. The leaves were prepared by roasting in clay vessels. Lime from burned ground shells was carried in a gourd provided with a paddle (Castellanos, 1886). This lime was mixed with coca leaves and chewed. Coca was burned as incense to idols (Piedrahita, 1942; Castellanos, 1886). Datura was used as a stupefying drug (Piedrahita, 1942; Castellanos, 1886). The Moscas gathered wax, honey and wild fruits (Piedrahita, 1942). Salt was extracted from salt water springs and pools. The salt water was placed over a fire in rough pottery vessels of various sizes and evaporated. It was necessary to break the vessels in order to extract the salt (Castellanos, 1886; Piedrahita, 1942). Hunting was a diversion as well as a source of food supply. Deer were plentiful in the mountains and furnished one of their fresh meats. Rabbits were hunted in the open country with slings. The Mosca also utilized bear, puma, jaguar, and guinea pigs for meat or hides. Fish and some birds were also eaten.

Shelter

Houses and palaces were round or oval shaped in floor plan. The roof had four rafters giving the top the effect of a pyramid. The roofs were thatched with grass. The house walls were formed of posts placed on end with a facing and a lining of canes tied with agave cord fibers. Spaces were filled with a mixture of clay and grass. Floors were sometimes covered with a layer of dried esparto grass as a carpet. Windows and doors were small. Openings could be closed by doors of canes tied with agave fibers in either solid or lattice work effects. Doors were provided with locks or latches made of wood. Wind screens of reed grass were placed back of the entrance (Piedrahita, 1942). Ordinary dwellings had at least two rooms, one for the man and another for his wives (Epitome, 1920). Temples were very large constructions but built of wood with thatched roofs. The palace of the Cacigue at Bogota had fourteen doors (Piedrahita, 1942). The temple at Sogamoso burned for five years according to Castellanos (Castellanos, 1886; Piedrahita, 1942). It was the custom to bury a live slave under the temple posts (Piedrahita, 1942). The interiors of the temples were so divided into passages and rooms as to resemble a conch shell (Piedrahita, 1942; Epitome, 1920), or a labyrinth (Epitome, 1920).

Some of the towns in the valleys were very large. Bogota had more than twenty thousand houses or families. Some other cities were almost as large (Piedrahita, 1942). They were surrounded by a stockade of large timbers, stood on end, and partly sunk into the ground. These were placed about eighteen inches apart, with the spaces tightly packed with canes held together by strong cords or ropes of agave or esparto fiber. Large red banners that looked like sails were hung from these masts (Castellanos, 1886). What looked like sentry boxes hung on some of these poles. These boxes served a different purpose during some of the Mosca ceremonies. Slaves or captives were placed in the boxes and killed with long lances (Castellanos, 1886). These large towns with their walls and masts reminded the Spaniards of castles. Some of the smaller villages in the northern part of Mosca territory were built among the rocks for protection.

Dress and Ornament

The early Spaniards were impressed by the richness of the clothing and ornaments of the Moscas. Clothing styles were uniform, being in imitation of the clothing said to have been worn by their God Bohica when he first appeared in their territory. The Moscas had no wool (Aguado, 1916). Their clothing was of woven cotton or of animal skins. Designs were painted on the cloth with a brush in black or red. The red color came from bija (*Bixa orellana*) and black color came from jagua (*Genipa americana*). Designs denoted the rank or position of the wearer. Men wore a square or rectangular piece of cotton cloth wrapped around their waist forming a tubular skirt or tunic reaching to their knees. The upper part of the body was covered by another square of cloth that was knotted on the shoulder. Women wore a tubular skirt formed from a square of cotton cloth fastened at the waist with a sash. Over their shoulders they wore a square mantle. This was fastened above the breasts with a large gold or silver pin, often so as to leave the breasts visible. This pin was sharp and had a large knob for a head. The pin point was used to extract niguas, little vermin that buried themselves under the skin of the feet of the Moscas who always went barefoot. They went barefoot, not because they did not know of sandals from neighboring tribes, but because the legendary Bohica never wore anything on his feet. Usually the Moscas wore either a cotton head band or a cotton hair net (Epitome, 1920). The head band often had a rosette of feathers in the center that fell over their eyebrows. For certain occasions or ceremonies they wore caps or helmets of wild animal skins such as bear, puma, or jaguar (Piedrahita, 1942). Priests and chiefs wore golden crowns or mitres for certain ceremonial occasions. Mourning cloaks were dyed red with bija (Castellanos, 1886). Shoulder bags of cotton and gourds were usually added as containers in which to carry various articles (Piedrahita, 1942). Both sexes wore their hair long as Bohica had worn his. Hair was always kept well groomed and often dyed to make it black and lustrous. Cropped or disheveled hair was a disgrace and used as a punishment (Epitome, 1920; Piedrahita, 1942). Clothes formed the greatest wealth of the Moscas and tearing or disfiguring of clothes was a most effective form of punishment.

The Moscas had a great wealth of personal ornaments (Piedrahita, 1942). Each purchased as much as he could afford within what his rank would allow him to exhibit. Breast ornaments were made from gold and silver. Circlets of gold studded with jewels were worn on the head. On the forehead a half moon of gold was placed with the points turned upwards. Small gold tubes were strung and worn at temples, wrists and neck. Bead bracelets were made from jewels, stone, and bone. Head dress was ornamented with bright feathers of many colors. Ears and the septum of the nose were pierced and pendants or plugs were placed in the holes. Designs were painted on the face and body with bija and jagua. Emeralds were the most striking of their ornaments and had a religious significance to the Moscas. They were burned or ground into powder as sacrifices (San Martin and Lebrija, 1916).

Technology and Trade

The Moscas used gold, silver, copper, and lead but gold was of greater value and religious significance (Castellanos, 1886). Metal work for idols and animal figures was considered by the Spaniards to have been rather badly done (Piedrahita, 1942). Some gourds full of little discs of gold were found which might have been used as we use coins. Probably this was only a convenient method of storage and transportation. Metal was used almost exclusively for ornamentation. The best emerald mines were said to have been in the area under the control of the city of Tunja Mines of Somondoco. Emerald mining was carried out in the rainy season when waters were high. The miners were looked upon as wizards or

sorcerers (Epitome, 1920). Ditches were dug to lead the water to the veins of clay that contained the jewels. The clay was loosened by prodding with wooden tools and the emeralds were washed out. White cotton textiles were woven (Epitome, 1920). Decoration was by brush painting with no dyeing of cotton before weaving. Pottery was coarse with little decoration. It was used for cooking, roasting coca and evaporating salt water from salt water springs. Large pottery jars were placed at temples and sanctuaries to receive offerings.

Trade formed an important part of the life of the Moscas. Certain days were set aside for markets and fairs (Castellanos, 1886). Some villages along the borders of Mosca territory were maintained as trading places (Piedrahita, 1942). Cargocarriers or bearers were trained from childhood (Piedrahita, 1942). The region of the Moscas furnished the finest and largest supply of salt for the whole surrounding country. Special salt roads or trails were developed with shelters constructed at intervals. Prepared coca formed one of the important trade items. Raw cotton came into, and finished cloth was traded out of Mosca territory. While the Moscas mined gold in their own territory, their insatiable Gods forced them to seek to acquire more from the outside. Having one of the main sources of emerald supply, the Moscas traded some of these with other groups (Castellanos, 1886).

Marriage and Burial Customs

Because the Mosca marriage customs differed so greatly from European customs, the Spaniards maintained that they had no marriage ceremony at all (Piedrahita, 1942; Epitome, 1920). The Moscas really had a system of bride purchase. A suitor approached the father or person who stood in the place of the father of a prospective bride and made an offer of a certain amount of valuables. If this were refused, he returned with a second and higher offer. On this being refused he returned with a third and final offer. If this third offer were refused, the whole affair was ended. If the offer were accepted, the bride was placed at the disposal of the suitor for a certain length of time. At the end of this time he could either keep the bride as his permanent wife or return her to her father. In this way some men kept up a kind of successive polygyny only limited by the extent of their resources (Castellanos, 1886; Piedrahita, 1942). One ceremony of the Moscas could be called a marriage ceremony but in many ways it is more like a change of status ceremony. As shown in some of the laws and religious ceremonies a rather clear distinction was made between married men and those men who had never participated in sexual intercourse. The following ceremony was performed only on the occasion of a man's first marriage. During the ceremony the couple stood before the priest with arms on each other's shoulders. The priest raised his hands above them. Most of the questions were addressed to the woman: "Will you love Bohica more than your husband?" "Yes." "Will you care more for your husband than for any children that you might have?" "Yes." "Will you care more for your children than for yourself?" "Yes." "If your husband dies will you cease to eat?" "Yes." "Will you promise not to go to the bed of your husband unless he first calls you?" "Yes." Then the priest turned to the man and told him that if he wished the woman he was embracing he should so proclaim in a loud voice. The groom then shouted his desire in a loud voice three or four times and the ceremony was ended. After this ceremony a man was permitted to have as many wives as he could obtain and sustain (Piedrahita, 1942). Several wives appear to have been usual, with the chiefs having two to four hundred. Women maintained a close relationship with their own ancestral family. The husband was responsible to the wife's family for injury to her. Incest rules for the common people extended to sisters, cousins and nieces. Rulers were excepted from incest rules, marrying full sisters and other very close relatives.

Burial customs varied, apparently both with rank and location. Interment

was sometimes practiced. The sign of the cross was placed on the graves of those who died from snake bite (Piedrahita, 1942; Castellanos, 1886). In some places special sanctuaries were erected. In the sanctuaries bodies were placed on platforms. The dead were wrapped in their finest clothes. Precious ornaments and offerings were placed with them. Another form of burial was in sacred lakes; jewels, ornaments and other offerings were placed in specially constructed containers along with the body and this was conveyed by raft into deep water and there sunk beneath the surface (Epitome, 1920). In some places the dead were taken to certain high places in the mountains and left there (Aguado, 1916). The burial of a deceased ruler of Bogota was quite an elaborate affair. A very good description of this rite has been left by Castellanos (1886). At death the body of the chief was turned over to the priests. In a secret place the priests had already, while the chief was still alive, prepared a deep excavation; in fact the preparation had been started as soon as the chief had been chosen. In the very bottom the chief's body was placed on a low golden stool. Around him were placed jewels, gold ornaments and all that was considered to be necessary to his maintainance in his proper sphere. This layer was filled in and covered with earth. In the next layer three of four of his favorite wives were buried alive, usually by their own choice. This layer was filled in with earth. Over this a group of slaves who had best served their master were placed alive and covered with earth. The whole excavation was then filled and all signs of disturbance were as far as possible removed. Before being buried alive the wives and slaves were given a drink made from an infusion of Datura and chicha beer in order to stupefy them. All layers were plentifully supplied with gold and jewels.

The Moscas believed in life after death. All the necessities for life, the planting and cultivation of crops, and the performance of ceremonies were buried with them. In the land of the dead, far away, people had to cultivate the land and raise crops just as they had to in the land they had left. The Moscas also believed in a universal judgment and a resurrection at which the dead were to return in the same being and beauty they had had when they died (Piedrahita, 1942). Red was the mourning color (Castellanos, 1886). Blankets, clothes, hair and body were dyed and painted red with bija.

Political Institutions

Political government differed between Tunja to the north and Bogota to the south. At the time of the coming of the Spanish invaders the Moscas seem to have been divided in allegiance between these two (Epitome, 1920). Bogota was a feudal state under an absolute monarchy; Tunja controlled an alliance of free "cities" (Piedrahita, 1942). Bogota rulers married many wives while in the free cities rulers were often celibate with succession going to sisters' sons, or to brother, preferably the older. In Bogota succession was also to sisters' sons or to brother. Sons could only inherit personal property (Castellanos, 1886). In Iraca to the north succession was by some sort of an election, not by the people, but by representative members of the ruling class of the various cities concerned (Piedrahita, 1942). The presumptive heirs to power, both male and female, were put through a rigorous training period lasting about six years (Castellanos, 1886; Epitome, 1920). During the six years they were never permitted to see the sun. They underwent long fasts and many foods were taboo to them. The training was under the charge of the priests and the rulers-to-be were put through many hard tasks under their tutelage. All relations between the sexes were prohibited during the training period. At the end of the training the graduate was equipped with all the gorgeous trappings he was entitled to as a future ruler. He was ceremoniously married to his first wife; afterwards he might take as many wives as he wished but the first wife always remained the most important. If a ruler's first wife died before him, she was permitted to impose a limited period of continence upon him. This

apparently assured her proper treatment (Castellanos, 1886; Epitome, 1920). The ruler of Bogota was an absolute monarch. He had the right to claim any or all of the daughters of all of the local chiefs under his control. Life and property were subject to his orders and no local chief could be confirmed without the approval of the ruler of Bogota (Castellanos, 1886).

One of the main diversions of the ruling class was traveling to special bathing spots. At one of these bathing places a hot and a cold spring were very close together. Specially constructed roads, as wide as a double carriage road, led to the bathing spots. The chief traveled to the bathing places carried in litters that were covered with gold, jewels and ornaments; slaves went in front clearing the road and covering it with grass and flowers.

Lust for women was considered by the Moscas to be a source of great danger in a ruler. Control of sexual manifestations was a great virtue. In the event that a ruler or lesser chief died without leaving a legal heir a significant test was used to determine the succession. Two possible rulers were chosen. They were stripped and brought before the judges or some higher chief. Beautiful maidens completely unclothed were brought in. The contestant who exhibited no signs of sexual excitement was declared the winner. If both failed, a new pair was chosen and put through the same test. This was continued until someone passed the test (Castellanos, 1886).

The activities of the common man were regulated by custom. Time was divided into a month of about 28 days. The first ten days were spent in ceremonial observations in which coca chewing played an important part. The next ten days were used to cultivate crops. The rest of the month a man spent at home with his wife or wives (Epitome, 1920). Land seems to have been held as private property by the men. Inheritance was usually to sisters' sons or to brothers. Type of clothing, painted designs and ornaments permitted were regulated by rank. Only the very powerful could be carried in litters.

Laws

A code of laws proclaimed by Nemequene, one of the last rulers of Bogota, has been passed on to us by (Castellanos 1886; Piedrahita, 1942). *1.* Murder carried the death penalty. Wife, father or other close relatives of the murdered one could not pardon the murderer. The supreme being gave life and man did not have the power to forgive one who took life away. *2.* Rape, if committed by a man who had never been married, should be punished by the death penalty. If rape were committed by a married man, two bachelors who had never been married were permitted to sleep with the offender's wife (probably his official or first wife). This was considered to be a punishment worse than death. *3.* Incest with a mother, daughter, sister or niece was punished by putting the guilty parties into a narrow pit filled with water. Snakes and obnoxious insects were placed in the water with the victims. A lattice-like cage was placed over the top and the criminal was left to perish miserably. The woman was given the same punishment because she was supposed to have awakened the desires that caused the breaking of the incest taboo. *4.* Homosexuality carried the death penalty. The manner and degree of punishment was left to the judgment of the chief. Punishment was usually very drastic and the practice of homosexuality which flourished in some of the surrounding areas was almost absent among the Moscas. *5.* It was ordered that if a married woman died in childbirth, her husband should lose one half of his land. This went to the parents of the wife, her brothers and sisters, or to relatives that stood in the place of parents. The husband was not considered to be guilty of any offense but the loss was supposed to be to the woman's family. If the child lived and the mother died, the father was only accessed the cost of raising the child. *6.* The eyes of a thief were put out by fire. If the offense was very grave or was repeated, the eyeballs were punctured with the

point of a thorn. The criminal was allowed to remain alive. *7.* No one except the ruler of Bogota or those to whom he gave express permission could be carried in litters. This permission was often given for exceptional service to the central government. *8.* Type of clothing, painted designs, and jewels that could be worn were limited by law, forming observable ranks or grades of importance. The upper ranks, the most illustrious and therefore nobles, were permitted by law to pierce their ears and nose and to wear whatever jewels they wished as nose and ear pendants. *9.* The estates of those who died without legitimate heirs were to be applied to the royal treasury. Legitimate heirs, according to the code, were nephews, brothers, and sons. *10.* Those who showed cowardice when called to war or when engaged in battle were ordered to wear the clothes of women and to do the work of women for a period of time to be set by the judgment of the chief. Anyone who fled the battle before his captain gave the signal to retreat was to be given an ignominious death on the spot.

Ruination and tearing of clothing and shearing of their long hair were considered to be most disgraceful punishments by the Moscas. Other punishments are shown by the many gallows placed along the roads by the Moscas. Criminals were sometimes placed in the so-called sentry boxes erected on the tall masts. These criminals were pierced by long lances with fire hardened points. The blood dripping down was caught in clay vessels for ceremonial use (Epitome, 1920).

Weapons and Warfare

Warfare, both internal and external, held a large place in the culture of the Moscas. Armies were formed into groups or companies according to type of weapon used such as slings, atlatls and darts, bows, lances and others. Each division carried a banner (Piedrahita, 1942). Distinctive head dress denoted the side a warrior was fighting on. Leaders were carried into battle on special fighting litters. The preserved bodies of former great warriors were carried in front of an attacking force, sometimes on litters, much as the story of the Cid in the history of Spain (Castellanos, 1886). In one great battle Bogota is said to have had a force of sixty thousand warriors; Tunja, a force of forty thousand warriors.

Slings were used for hunting in open country and slingers were organized into groups in warfare. The bow and arrow was also used for fighting from a distance. Swords or macanas were made from hard chonta wood. These double edged swords were larger than a fencing broad sword and were polished and sharpened almost like steel. Lances or spears were made of wood with fire hardened points. The main weapon of the Mosca fighting forces was the atlatl or spear thrower dart of various weights. The spear thrower was used for close contact fighting. The Moscas' armor of padded cotton could not resist these darts.

Darts and arrows were made from three different pieces. The points were made from the same extremely hard wood as the swords with the tip hardened in the fire. A section of a different wood (jaculillo ?), about two palms long, was fastened next to the point as a foreshaft. The rest of the shaft was of cane. The atlatl was of the so-called male type with a peg projecting from each end at right angles and in the same direction. One peg engaged a notch in the end of the dart and the index finger was hooked around the other peg (Aguado, 1916; Castellanos, 1886; Epitome, 1920; Piedrahita, 1942).

The Moscas were engaged in almost constant combat with the Panches, a savage cannibalistic tribe to the southwest. Crack troops were posted along the frontier as border guards (Castellanos, 1886; Piedrahita, 1942). For each Panche that he killed, a "Quecha" or border guard was permitted to hang a pendant from a hole pierced in his ear, the septum of his nose, or around his mouth. Many had the rim of the ear completely circled by small golden ornaments. The heads of the Panche warriors slain in combat were removed by the Moscas and carried

back to be placed in sanctuaries in Mosca territory. Youths young enough to appear to have never had sexual intercourse were captured alive and taken to the mountains to be sacrificed to the sun because the sun is a cannibal and likes tender meat (San Martin, 1916).

For twenty days before attempting an expedition into enemy territory, the Moscas held a ceremony in front of one of their sanctuaries. They sang and danced, relating their grievances and asking for victory. Upon return another twenty days were spent before the sanctuary, either in rejoicing for a victory or in lamentation of a defeat (Epitome, 1920).

Religion

The Moscas had a highly organized and complex religion which was common to the whole group. All warring factions acknowledged a high priest or "Pontifex Maximus" at Sugamuxi (Piedrahita, 1942). Religious and governmental control were in separate hands, especially in Bogota. The Moscas believed in a creator who had created all of nature, in the immortality of the soul, in the resurrection of the body, and in a universal judgment. Men who died in battle and women who died in childbirth were exempt from judgment for their sins (Epitome, 1920). The sun which was male and the moon, a female, were objects of worship. The sun and the moon had sexual intercourse when the nights were dark (Epitome, 1920). Some mountains, rivers, lakes, and groves of trees were thought to be sacred (Piedrahita, 1942).

Enormous temples of wood, thatched with grass were erected, the greatest of which were at Bogota, Guatavita, and Sogomoso. Large timbers brought up from the llanos were used in construction. A living slave was buried under each of the temple posts. A road one hundred leagues long was built leading from the llanos to Sogomoso for this was their most sacred temple (Piedrahita, 1942).

The Moscas greatest worship was reserved for Bohica, a stranger who came into Mosca territory from without. He lived among them for two thousand years doing and teaching good, then ascended to the sky. There is some argument as to whether the legends of Bohica represented one man or three men. The greatest agreement is that there was only one man who had been given three different names at three different places. Bohica wore his hair long. His beard reached to his waist. He wore a braided head band with a rosette of bright feathers in the front falling over his eyebrows. Bohica wore a mantle tied with a knot on the shoulder; he always traveled with his feet bare. Before he ascended to the sky, Bohica left many prophecies and chose a successor. Bohica spent his last days on earth at Sogomoso. The priest at Sogomoso was his successor and as such high priest of all the Moscas (Piedrahita, 1942).

The Moscas have a tale of the flood (Piedrahita, 1942; Castellanos, 1886). At one time an evil supernatural being caused the plains of Bogota to be flooded forcing the people to flee to the mountains. Bohica appeared and cleft the mountain range, forming the river Funza which drained off the water. This was the origin of the famous falls of Tequendama.

The Moscas were idol worshippers. In addition to the great temples many smaller oratorios or sanctuaries were erected to house these idols which were made of metal, string, wax, wood or clay. They were ornamented with jewels. Idols were made in figures of the sun and the moon and of human beings. The figures were usually poorly carved. Human figures were made in various sizes, large and small. They were placed in pairs, always a male and a female figure together. These figures had long hair and were clothed in cotton cloth decorated with designs painted on with a brush (Piedrahita, 1942; Castellanos, 1886). Each Mosca had an individual idol of his own that was always with him. These personal idols were thought to be especially effective as protection in battle. Personal idols were of gold if this could be afforded. They always contained an emerald or other

jewel. A poor man made his personal idol of wood and ornamented it with such jewels as he could obtain (Epitome, 1920).

The priests of the temples were called "chuques" by the Moscas. These priests lived in the temples. They were not allowed to marry but had to lead a celibate life. If even suspected of a transgression of the rules of celibacy, they were deprived of their office. The priests who were consulted on the gravest matters, received the offerings to the Gods, and performed the ceremonial rites of sacrifice should have clean, not polluted hands. The priests ate, talked, and slept very little. They lived a life withdrawn from worldly affairs. Most of their nights were spent chewing coca which they themselves gathered and prepared (Piedrahita, 1942). The priests were all diviners, making the offerings to the Gods and giving the people answers to their questions. Offerings to the idols were of gold, powered or nugget, emeralds, either whole or pounded into powder, and golden figures of animals such as snakes, toads, lizards, ants, caterpillars, monkeys, and foxes. Jewels were sometimes thrown into the fire as an offering to the gods. Golden helmets, bracelets, diadems, and vessels were offered. Of less importance were offerings of animals such as pumas, jaguars, bears, deer and of pottery vessels. Some of the pottery vessels were empty, some filled with food. A large pottery vessel was usually placed in front of the sanctuary to receive the offerings.

The priests made human sacrifices. Only a very powerful and wealthy chief could afford to offer a human sacrifice. Most of the chiefs made only one sacrifice during their reign, a few made two. The youths to be sacrified were purchased from a village distant from Mosca territory. This village either captured the youths or traded for them from other tribes. The youths were taken to the temples when they were under ten years old and very carefully cared for. They were sacrificed when they were fifteen or sixteen years old. If they by any chance were suspected of having had sexual intercourse with any woman either inside or outside of the temple, they were not considered to be fit to be sacrificed to the gods but were reserved for another fate. In the sacrifice to the sun the victims were cut open while still alive and their hearts and entrails torn out (Aguado, 1916; Castellanos, 1886; Epitome, 1920; Piedrahita, 1942).

Men and women had to observe certain rites and ceremonies before they went to the temples with their offerings and sacrifices. They had to fast many days, some days without eating anything at all, other days without meat or fish, only certain herbs or plants, without salt or peppers. They withdrew from all affairs; men and women had to stay apart. To break their fast in any way would be to risk death. During the fast they could not wash their bodies. At the end of the fasting which they called the "zaga" they went to the temple and handed over their offerings to the temple priests. The priests then offered the presents to the Gods at the same time asking the questions that had been passed to them by the people. The priests then came back to the people and gave them their answers, the priests having performed the ceremonies in seclusion (Castellanos, 1886; Piedrahita, 1942). When the supplicants had received their replies they went home happy and consoled. There they bathed using a special soap made from the fruit of the guava tree. They dressed in new clothes and called in their relatives and friends for a feast. At these feasts great quantities of chicha beer were consumed. There was dancing, men and women together. Music was played on shells and flutes. The people sang verses or songs together with a certain measure of consonance, much like a carol or sea chanty (Castellanos, 1886; Piedrahita, 1942). Working parties used this same measured chanting as a rhythm for concerted action. The priests were also the physicians, using herbs as well as magic. They had charge of the training of the rulers and took care of the dead. To ward off frost, a priest would perform a ceremony under a white cotton blanket (Castellanos, 1886).

The most imposing ceremony of the Moscas took place at the time of planting and of harvesting (Piedrahita, 1942; Castellanos, 1886). This took the form of a procession along a road that was constructed for this purpose alone. This road was a half a league long and very wide. Sometimes ten or twelve thousand persons participated in these parades and multitudes of spectators lined both sides of the roadway. The chiefs took part in these processions and played a more important role in them than the priests.

The priests led the way with gold crowns shaped like mitres on their heads. Then came a group without clothes or ornaments, their bodies painted with bija and jagua. This naked group was weeping and crying, calling on the sun and the Gods to save them. The next group was shouting and laughing, their clothes disarranged, happy because the prayers of the group in front of them had been answered. Then came groups in various costumes, some in the skins of pumas, bears, jaguars, and other animals. Some groups were masked. At the rear came the chief and all his nobles and court retainers, each dressed in a manner so as to show his exact rank. There was a great display of wealth in gold and jewels and all other valuables that the Moscas possessed. After the parade an all night celebration with beer and dancing was held.

CONCLUSION

The Moscas formed a large assemblage of peoples sufficiently organized to be assigned the designation of statehood. Their common religion held them together even during the viscisitudes of internal strife. Government was organized in such a way so as to be partially outside of religion. There was a recognition of a duty to and a power of the state above and beyond the allegiance owed to a hereditary ruler. There was little indication of true democracy. The principles of both a sovereign ruler and federation of free cities can be recognized. While Mosca technology was far below that of Meso-America and the Andean region of Peru, their cohesive organization into the semblance of a modern state was well advanced.

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Biology For You. *B. B. Vance* and *D. F. Miller.* J. B. Lippincott Co., New York. 4th Ed. x+654 pp.

"Biology for You" has been prepared by a teacher of high school biology and a teacher of teachers of high school biology. It is designed to present the science of biology in such a form that high school students will become interested in the subject, and, with an extensive series of excellent photographs (many in color) and drawings to maintain interest, will become informed about the living things about them.

The fourth edition excels earlier ones in several respects. It has been brought up to date (3rd edition, 1946); it has a better grade of paper for the use of photographs; and there are many new well-selected illustrations. It is an outstanding aid to high school teachers and a book for their students.

THOMAS H. LANGLOIS

A COMPARATIVE STUDY OF THE MECHANICS OF FLYING AND SWIMMING IN SOME COMMON BROWN BATS

THOMAS J. CRAFT, MARIAN I. EDMONDSON, AND ROBERT AGEE
Central State College, Wilberforce, Ohio

Although bats made their appearance upon the earth more than a million years ago, the first known reports of North American bats having the ability to swim were reported by Craft and Dexter (1955) and Patten and Patten (1956). The data reported here attempt to give comparative measurements of some of the anatomical mechanics involved in flying and swimming in *Myotis sodalis* and *Eptesicus fuscus*. It is also apparent that this situation presents an excellent opportunity to compare some of the physiological differentials of an animal performing a function for which it is accustomed and primarily adapted, with one for which it is neither accustomed to performing nor primarily adapted. A comparative study of some physiological stresses evidenced during flying and swimming in bats is currently under study in our laboratory.

MATERIALS AND METHODS

The *Myotis sodalis* used in this investigation were collected from Carter Caves located in northeastern Kentucky. Seventeen specimens were collected January 6, 1956, and thirteen specimens were collected March 25, 1956. Twenty-three specimens of *Eptesicus fuscus* were collected from a stock barn in Greene County, Ohio during October 1956. It was standard procedure to determine the sex, weight, body length (snout to vent) and the forearm length of each animal. The animals were not fed during the tour of investigation. The bats were stored at 4 ± 2°C. One hour prior to any given test the specimens to be tested were removed from the temperature of 4 ± 2°C to one of 22 ± 2°C. Burbank and Young (1934), Evans (1938), and Hock (1951) have agreed that the body temperature of bats remains within one or two degrees centigrade of the atmospheric temperature when the bat is inactive. We found sixty minutes to be sufficient time for the temperature to change from one of approximately 4 to 6°C to one of 22 to 24°C. We also found 22°C to be sufficient temperature to allow normal flight by the bats tested. However, Larsell and Dow (1935), as a result of observations made on a *Corynorhinus* sp., listed four stages of emerging from winter sleep, namely:

(1) when the temperature is below 0°C, rigidity is evidenced. Only the grasping reflex of the hindfeet is slightly evidenced.
(2) stage of medula reflexes, grasping reflex is fully exhibited. (atmospheric temperature above 0°C).
(3) at approximately 10°C, marks the beginning of cerebral activity and protective movements are evidenced.
(4) at approximately 35°C, marks the stage of awakening, all muscular activities are regained.

The bats were allowed to fly in a laboratory 10 x 7 x 3.3 m. They were allowed to swim in a tank 1.5 x 1 m containing approximately 6 ft^3 of tap water. The animals performed the operations of flying and swimming on different days. Observations on the mechanics of flying and swimming were made by motion picture photography. Pictures were taken at sixty-four frames per second.

RESULTS AND DISCUSSION

In the collections of *M. sodalis* sixty-three percent were male and thirty-seven percent were female. The collections of *E. fuscus* contained sixty-nine percent

male specimens and thirty-one percent female. The results of the observations made on their capacities to fly and swim have been tabulated in table 1.

Eisentraut (1936) showed in a set of motion picture figures that a large mouse-eared bat found in Germany made eleven or twelve wing beats (flying stroke cycles) per second while flying and in this time traveled about 420 cm. The flying and swimming stroke cycles are divided into a propulsion phase, which is responsible for the animals forward movement, and a recovery phase. The duration of the flying stroke cycle was observed to be the same in *M. sodalis* and *E. fuscus*, this being 0.109 second in each group. The propulsion phase required 0.062 second for its completion while the duration of the recovery phase was 0.047 second. There was a difference in the rate of execution of the swimming stroke cycle between the *M. sodalis* and *E. fuscus*. The pattern of the swimming stroke cycle was the reverse of the flying stroke cycle in that the recovery phase was 0.016 second longer than the propulsion phase. In *M. sodalis* the swimming stroke cycle lasted 0.172 second (fig. 1 to 11). The propulsion and recovery phases lasted 0.078 and 0.094 second, respectively. In *E. fuscus* the swimming stroke cycle lasted 0.203 second; the duration of the propulsion phase was 0.094 second, and the duration of the recovery phase was 0.109 second.

TABLE 1

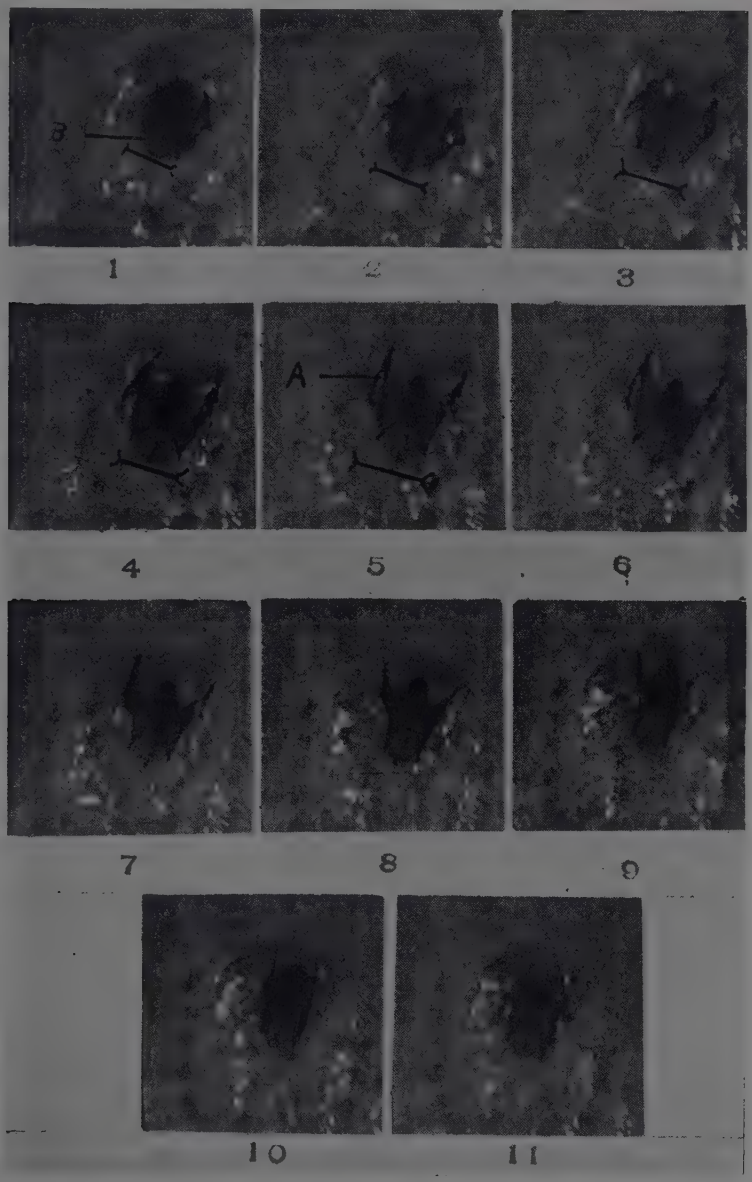
Flying and swimming in bats

Average Data	Number of observations	*M. sodalis*	Number of observations	*E. fuscus*
Weight	29	8.8 gm	23	21.75 gm
Combined length of head and body	29	81.9 mm	23	106.85 mm
Length of forearm	29	39.4 mm	23	46.8 mm
Rate of flying	15	2,986 mm/sec	18	3,671 mm/sec
Wing beats	15	9.1 /sec	18	9.1/ sec
Distance/wing beat	15	328 mm	18	403 mm
Rate of swimming	25	295 mm/sec	21	308 mm/sec
Wing beats	25	5 8 /sec	21	4 9 /sec
Distance/wing beat	25	53 mm	21	61 mm

During the swimming propulsion phase (fig. 1 to 5), the lateral extension of the uropatagium (fig. 1, B) increased as the wing unfolded latero-posteriad. The lateral extension of the uropatagium decreased during the recovery phase (fig. 6 to 11) and at this time the anterior appendages moved dorso-medio-anteriad. In *M. sodalis*, the distance traversed by the distal extremity of one forearm during a single swimming stroke cycle was equal to 88 percent of the body length. In *E. fuscus*, the distance traversed by the distal extremity of one forearm during a single swimming stroke cycle was equal to 87 percent of the body length.

During flight the tip of the uropatagium was curved ventrad thereby producing a dorsal arch on the body of the uropatagium. Such a position enabled the uropataguim to serve as a rudder. When the bat was swimming, the tip of the uropatagium was curved dorsad which produced a ventral arch in the body of the uropatagium (fig. 1 to 11). This position reduced the resistance of the water upon the forward movement of the bats's body as well as increasing the buoyancy effect upon its body. The ventral arch was deeper in the best swimmers. Without sufficiently ventral arched uropatagium the caudal end of the animal had a tendency to become submerged in the water at which time the animal began to flounder.

The bats tested did not swim with equal facility. Velocity was selected as a



The photographs were taken with a Bolex 35 mm motion picture camera at sixty-four frames per second. *Myotis sodalis* completing the cycle of a swimming stroke.

1 to 5 show the propulsion phase of the swimming stroke cycle.
A—wing B—uropatagium
6 to 11 show the recovery phase of the swimming stroke cycle.

basis for evaluation of the bats capacity to fly and swim. Three classifications of the ability to fly and swim were arbitrarily established as shown in table 2. In both species of bats tested, the style of swimming closely resembled the butterfly stroke employed by human swimmers. While both species resembled the butterfly stroke, the movements of *E. fuscus* resembled this style of swimming more closely than did those of *M. sodalis*. The forearms served as rudders during swimming. Both species were able to float without apparent difficulty. When floating, the wings were folded alongside the body; the uropatagium remained arched ventrad.

Upon comparing the distance traveled per wing beat to length of body, we found that based on the average rates of all members of *M. sodalis* tested, they flew 4 times the length of their body per stroke and swam 0.64 of their body length per stroke cycle. The members of *M. sodalis*, classified as good flyers, traveled

TABLE 2

Classification of swimming and flying in bats

Genera	Operation	mm/sec	Rating	% of animals in classification
Myotis	Flying	3,360–4,540	Good	22
		2,210–3,350	Average	66
		1,320–2,200	Poor	12
	Swimming	400–520	Good	30
		220–390	Average	46
		100–210	Poor	24
Eptesicus	Flying	3,360–4,540	Good	69
		2,210–3,350	Average	16
		1,320–2,200	Poor	15
	Swimming	400–520	Good	21
		220–390	Average	53
		100–210	Poor	26

a distance equal to 4.7 times their body length and those classified as good swimmers swam a distance equal to 0.98 of their body length. Based on the average rates of all members of *E. fuscus* tested, they flew 3.8 times their body length per stroke cycle and swam 0.57 of their body length. The members of *E. fuscus* classified as good flyers flew 4.4 times their body length. A good swimmer of the human species is expected to propel himself a distance equal to the length of his body per stroke cycle.

The bats did not improve their rates of swimming with practice. Those classified as good swimmers swam readily and did not flounder about the sides of the tank. Instead they swam on a straight course, with strong, graceful strokes, and with a deep ventral arch in their uropatagium. The hair of the good swimmers did not wet as easily as did the hair of the animals falling into other classifications. Apparently the sebaceous glands secreted a more resistant coating of oil onto the root sheath of the hair. This is in keeping with observations that have been made on aquatic birds. If the feathers of aquatic birds are not adequately preened, the birds fail in their attempts to swim. The weight and body length of the bats did not have a direct effect upon the rate at which they flew or swam.

It was observed in both species that females swam faster than males and that they had shorter forearms. The data in table 2 show that 50 percent of all animals tested flew and swam equally well: 33 percent flew better than they swam; and 16 percent swam better than they flew.

SUMMARY

1. Animals classified as good swimmers evidenced a deeper ventral arch in their uropatagium.
2. The hair of animals classified as good swimmers wetted less easily than the hair of those bats falling into other classifications.
3. Females of *Myosis sodalis* and *Eptesicus fuscus* swam faster than the males of the respective species.
4. The females of each species had an average forearm length that was shorter than that of the males in their species.
5. There was no apparent direct effect of body length and weight upon the bat's rate of flying and swimming.
6. The recovery phase of the flying stroke cycle of both species was 0.016 second shorter than the propulsion phase, but was 0.016 second longer than the propulsion phase during the swimming stroke cycle.
7. (a) According to our classification, 50 percent of all animals swam and flew equally well; (b) 33 percent flew better than they swam; and (c) 16 percent swam better than they flew.

ACKNOWLEDGMENTS

Miss Marian Edmondson and Mr. Robert Agee were undergraduate assistants during 1955–56 and 1956–57 respectively. Mr. Agee's present address is Meharry Medical College, Nashville, Tennessee.

The authors wish to thank the Central State College Committee on Faculty Research for financial support of this investigation. We also wish to thank Professors Ralph Dexter and Elizabeth Smith for advice and assistance in securing specimens, Mr. Theodore Green for his technical assistance with the photography, and Professor William C. Lucas, Jr., Central State College swimming coach for his observations on the swimming style exhibited by the bats.

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Poison on the Land. *J. Wentworth Day.* The Philosophical Library Inc., New York, N. Y. 1957. x+246. $6.00.

The jacket states that this book "gives a factual and documented account" of how present-day treatment of the land is threatening to kill many of our wild animals. In part this is true, but it appears that some of the "facts" are developed from evidence scarcely substantial in nature. Wildlife biologists should be concerned, as Mr. Day is, about the widespread and sometimes irresponsible field application of highly toxic insecticides and herbicides; however, much more information is needed before the total effect of such chemicals can be assessed. The need to proceed with caution until good information is available is apparent.

This book is particularly interesting in providing a comparison of British and American attitudes in game management. Readers unfamilar with European methods in this field may be surprised at the intensive measures advocated and the suprisingly large crops of game sometimes harvested.

In spite of occasional conclusions not well supported by data, the book is filled with interesting and useful information. It clearly points up the immediate need for more research.

E. E. Good

ANNUAL REPORT OF THE OHIO ACADEMY OF SCIENCE

1958

Organized 1891 Incorporated 1892

Affiliated with the American Association for the Advancement of Science

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THE OHIO JOURNAL OF SCIENCE 58(4): 250, July, 1958.

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REPORT OF THE SIXTY-SEVENTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

The 67th annual meeting was held on the campus of the University of Akron during April 10 to 12, 1958. It was the first Academy meeting to be held at that institution. A total of 488 registered for the meetings of the Senior Division. Dr. Walter C. Kraatz and his local committee made the arrangements for meetings, housing and dining facilities. Field trip arrangements were made by Professor Paul Acquarone for the sections of Zoology, Plant Sciences, and Conservation; by Professor Glen W. Frank for the section of Geology. The Executive Committee and the Council held meetings on April 10 for the transaction of business.

On Friday, April 11, ten sections and one subsection held meetings in the following fields: Zoology, Plant Sciences, Genetics, Geology, Medical Sciences, Physics and Astronomy, Geography, Chemistry, Science Education, Anthropology and Sociology, and Conservation. More than 150 research papers were presented and discussed. A special lecture, "Federal Program for Improving Science Education," was given by Dr. Bowen C. Dees, Deputy Director of the National Science Foundation, under the sponsorship of the section of Physics and Astronomy. Another on "Recent Advances in Rubber Chemistry," was delivered by Dr. James D'Ianni under the auspices of the section of Chemistry. Symposia and panel discussions were held in the sections of Geology, Physics and Astronomy, Geography, Chemistry, and Conservation. Throughout the day on Friday the Junior Division sponsored the Tenth Annual State Science Day in which 877 students from a record number of 233 schools participated. These had been selected from 4934 students who took part in the eight District Science Day meetings held earlier throughout the state. Sectional meetings were suspended at 11:00 A. M. to give all members of the Senior Division an opportunity to view the projects and exhibits of the junior members. Commercial exhibits were presented by several companies. A tea was held Friday afternoon for visiting ladies. Wives of faculty members of the the University of Akron and of Academy officers served as hostesses.

The annual banquet and business meeting were held in the University Club Friday evening. Dean Ernest H. Cherrington of the University of Akron served as toastmaster. Greetings from the University of Akron were given by President Norman P. Auburn and the response was made by Dr. Robert M. Geist who served as president of the Academy in 1956–1957. Dr. Walter C. Kraatz, president of the Ohio Academy of Science, delivered his presidential address entitled, "Pseudo-Science and Anti-Science in an Age of Science." Professor G. G. Acker, as Executive Secretary of the Junior Division, announced awards to outstanding high school teachers and science departments. At the business meeting officers were elected to serve for the coming year. Appointments were also announced. These new officers and

committee members are listed at the head of this annual report. A constitutional amendment, adding the Director of Public Relations to the membership of the Executive Committee, was approved. Ten members of the Academy were announced as newly elected Fellows. Their names and section letters are as follows:

F—Everett H. Bush	C—Wayne D. Martin
C—Charles E. Graham	C—George E. Moore, Jr.
G—Eric S. Graham	C—Floyd R. Nave
F—William N. Harris	H—Josephine Randall
I—Donald P. Irish	C—Warren G. Steel

Dr. R. V. Bangham presented a resolution prepared by the Resolutions Committee.

On Saturday the section of Physics and Astronomy held a joint meeting with the Ohio Section of the American Physical Society. The section of Geology held an all-day field trip, and another trip was sponsored jointly by the sections of Zoology, Plant Sciences, and Conservation.

Respectfully submitted,

George W. Burns, *Secretary*

REPORT OF THE EXECUTIVE COMMITTEE AND THE COUNCIL

The Executive Committee met on October 12, 1957, December 6, 1957 and April 10, 1958; the Council met on December 7, 1957 and April 10, 1958. The autumn meetings were held at The Ohio State University in Columbus and the spring meetings were held at the University of Akron. Following is a brief summary of the more important actions taken.

1. *Meetings of the Executive Committee.*—The temporary committee on Training and Certification of Science Teachers was asked to present a series of specific proposals on the State Department of Education requirements to the Council; this report is given under Committee Reports later in this Annual Report. It was agreed that the process of nomination of Fellows would not be reorganized. Dr. Ralph Dexter was continued as a temporary committee of one on Academy history. The Committee on Institutional and Corporation Members was also continued as a temporary committee. A proposed amendment to the Constitution making the Director of Public Relations a member of the Executive Committee was approved, and the Secretary was instructed to follow constitutional provisions in bringing the proposal before the membership. This amendment was subsequently approved at the annual business meeting of April 11, 1958.

Two gifts of $50.00 each were received from Dr. C. M. Goethe of Sacramento, California for the purpose of aiding married students with children in becoming members of the Academy. By April 30, 1958, eleven such memberships had been awarded. In view of reports submitted from the several sections, it was agreed to continue holding Junior Academy meetings concurrently with those of the Senior Division, and to continue the practice, begun in 1957, of adjourning morning sectional meetings at eleven o'clock to permit judging and viewing of the Junior Division projects and exhibits by members of the Senior Division.

Mr. Acker reported that work is progressing on a Junior Academy medallion for membership pins. An additional appropriation of $500.00 to the Junior Academy in whatever categories needed was made.

A temporary committee, consisting of Dr. Popham, chairman, Professor Acker and Dr. Geist, was appointed to study the possibility of creating the post of Executive Secretary of the Academy. The report of this committee, made in April, was accepted and presented to Council for its approval.

It was agreed that signers of petitions for the establishment of new sections must either be members of the Academy or submit with their signature on such petitions membership applications and payment of first year dues; they must also indicate their present sectional affiliation and whether they would transfer to the new section, if and when established.

2. *Meetings of the Council.*—Announcement was made by Mr. Acker of the establishment of a new district of the Junior Division, the North Central, with headquarters at Heidelberg College. A plea was made by the Director of Public Relations, Mr. Coash, for a better flow of publicity material from the Executive Vice-Presidents and for abstracts of papers which are condensations of those papers and which include the results of the research being reported upon.

After discussion of the report of the Committee on the Training and Certification of Science Teachers it was agreed to accept the report and, in conformity with the request of the committee chairman, to ask the president to appoint a new committee to continue the work.

Attempts to secure the fifty signatures to petitions requesting the establishment of a section of Genetics have not yet been successful, but efforts to do so will continue.

The report of the Committee on an Executive Secretaryship was accepted, and it was agreed that the necessary implementing committee be appointed as early as possible.

Reports were presented by all officers and committee chairmen. Their annual reports are

presented in the following pages. Membership in the Senior Division as of April 30, 1958 was 1272, an increase of 100 over one year ago.

The next annual meeting was scheduled for Capital University on April 16–18, 1959.

Respectfully submitted,

GEORGE W. BURNS, *Secretary*

REPORT OF THE TREASURER

FISCAL YEAR 1957

ACADEMY BUSINESS

	1957	*1956*
RECEIPTS:		
Bank Balance, January 1	$10,735.77	$ 4,803.54
Membership Dues	4,160.00	4,145.50
Sale of Publications	6.14	6.06
U. S. Bonds cashed	—	150.00
U. S. Bonds interest	47.50	47.50
National Science Foundation Grant	4,000.00	4,800.00
Gift—C. F. Kettering	—	1,000.00
Gift—C. M. Goethe	50.00	50.00
Junior Academy	1,022.00	801.15
Refund	10.00	—
From Res. Fund, BancOhio Stock	22.00	—
	$20,053.41	$15,803.75
EXPENDITURES:		
Subscriptions and Engraving, Ohio Journal of Science	$ 3,068.54	$ 2,089.62
Printing Annual Report	165.51	261.70
Printing Announcements and Notices	215.00	434.38
Public Relations	65.92	—
Postage, office supplies, bank charges, auditing and other administrative expense	1,049.05	596.50
National Science Foundation Grant	2,675.93	704.87
Junior Academy	1,320.97	958.91
Academy Conference	11.50	—
BancOhio Stock	37.84	22.00
Modern Finance Co	8,000.00	—
Bank Balance, December 31	3,443.15	10,735.77
	$20,053.41	$15,803.75
Excess Income over Expense	$ 707.38	$ 5,932.23

RESEARCH FUND

RECEIPTS:		
Bank Balance, January 1	$ 448.79	$ 121.44
Interest, Savings Account	83.17	73.64
U. S. Bonds Cashed	—	100.00
U. S. Bonds Interest	5.00	7.50
BancOhio Dividends	44.60	41.25
Grant, A.A.A.S.	—	255.00
Bank Service Overcharge	3.69	—
	$ 585.25	$ 598.83
EXPENDITURES:		
Grants	$ —	$ 105.00
Bank Service Charges	1.00	5.75
Interest still in Savings Account	83.17	39.29
BancOhio Stock to Academy	22.00	—
Bank Balance, December 31	479.08	448.79
	$ 585.25	$ 598.83
Excess Income over Expense	$ 30.29	$ 327.35

Respectfully submitted,

ELTON F. PADDOCK, *Treasurer*

REPORT OF THE ACADEMY LIBRARIAN

The Academy's *Ohio Journal of Science* is now being used to obtain exchange publications from a total of 543 institutions (135 domestic and 408 foreign). This represents a net total increase of 16 over a year ago, although 18 new institutions have been added, bringing in 32 new titles in exchange. Two foreign institutions were dropped from exchange, one because its publication ceased and the other because of its merger with another division.

A total of 16 Special Papers were sold through the Gift and Exchange Division of Ohio State University Library, bringing in a revenue of $16.92.

The Librarian would also like to place on record his thanks to Miss Mary B. Pinson, Gift and Exchange Librarian, Ohio State University, who carried on the actual work of exchanges while he was employed in another department and not able to maintain constant contact with the work.

Respectfully submitted,

DONALD J. PEARCE, *Librarian*

REPORT OF THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The annual meeting of the Joint Administrative Board of The Ohio Journal of Science was held at Columbus on March 1, 1958. The meeting was called to order by Board Chairman Meyer. Present were Mr. B. S. Meyer and Mr. Robert L. Bates, representing The Ohio State University; Mr. C. E. Hoel, representing The Ohio Academy of Science; and Mr. H. L. Plaine, Mr. T. H. Langlois and Mr. R. A. Popham of The Ohio Journal of Science staff. Mr. Warren P. Spencer was unable to attend.

Minutes of the last meeting were approved as read.

The report of the Editor, Mr. Plaine, was approved as read. A copy of this report is attached to these minutes. The Editor indicated that the Journal is only 4 to 6 months behind in the publication of papers and book reviews. This time delay in publication of papers is considered to be about minimum.

The Book Review Editor, Dr. Langlois, reported that 44 book notices had been published in Volume 57. He also indicated that forthcoming issues of the Journal will carry lists of books which have been received and which are considered to be appropriate reading for scientists.

The report of the Business Manager was approved as read. This report which accompanies these minutes, is mainly in the form of a financial statement for Volume 57. Mr. Popham reported that had it not been for a contribution made by Charles F. Kettering through The Ohio Academy of Science, The Ohio Journal of Science would have shown an excess of expenses over income. He pointed out the necessity for seeking an additional source of income for 1958. The circulation of the Journal was reported to be approximately 1880.

The following staff members were elected for the year 1958–1959: Mr. Plaine, Editor; Mr. Popham, Business Manager; and Mr. T. H. Langlois, Book Review Editor.

In asking for nominations for Chairman of the Board for the year 1958–1959, Dr. Meyer indicated that he intended to ask President Fawcett to appoint some person to replace him on the Board. Dr. Meyer expressed the feeling that tenure of board members appointed by the President should be for definite periods of time and suggested the possibility of three-year appointments. Mr. Charles E. Hoel was elected Chairman of the Board for the year 1958–1959.

Dr. Meyer stated that he would appoint a committee to audit the books of the Business Manager for the year 1957. He indicated that the committee members would be Mr. S. S. Humphrey, and Mr. Wilbur Tidd.

After some discussion of the financial condition of the Journal and prospective expenses of the Journal during the year 1958, Mr. Popham was instructed to ask the Executive Committee of The Ohio Academy of Science to approve the Joint Administrative Board's request to allow The Ohio Journal of Science to seek a gift of necessary supplementary funds for the operation of the Journal from the Kettering Foundation directly. If the Executive Committee grants the request, Mr. Popham was instructed to request the sum of $1,000.00 from the Kettering Foundation for the year 1958.

Mr. Popham was instructed to write a letter to President Fawcett of The Ohio State University requesting the sum of $2500 from the University in payment of subscriptions which the Library uses as a basis for exchanges with other scientific organizations and publications. After some discussion of editorial matters and format of the Journal, the Board instructed the editor, business manager and book review editor to make any changes which they deem desirable with respect to the color, and finish of the paper used for the cover of the Journal.

Respectfully submitted,

RICHARD A. POPHAM, *Secretary of the Board*

THE OHIO JOURNAL OF SCIENCE

VOLUME 57—FISCAL YEAR 1957

BALANCE SHEET

RECEIPTS	
Bank balance at beginning of period	$2,751.32
O.S.U.—paid for subscriptions	2,500.00
O.A.S.—paid for subscriptions	2,009.00
Non-members—paid for subscriptions	663.90
Separate numbers, volumes and reprints sold	210.75
50 year index sold	20.00
O.A.S.—paid ½ cost of plates	259.54
O.A.S.—paid for annual report	165.51
Miscellaneous	67.53
Advertisements	447.18
Charles F. Kettering—Gift	800.00
	$9,894.73
EXPENDITURES:	
Spahr and Glenn—printing O.J.S.	$5,482.91
Bucher Engraving—plates	664.80
Postage and express	240.74
Labor	52.50
Office expenses and bank charges	145.69
Advertising of the O.J.S.	10.00
Reprints	0.00
Mailing envelopes	255.37
Refunds	1.00
Miscellaneous	67.53
Bank balance at end of period	2,974.19
	$9,894.73

THE OHIO JOURNAL OF SCIENCE

REPORT OF THE EDITOR OF VOLUME 57, 1957,
to the Joint Administrative Board

Volume 57 of The Ohio Journal of Science contained 408 pages, of which 354 pages were devoted to 41 scientific papers in 8 fields of science (as designated by sections of The Ohio Academy of Science); 16 pages were devoted to affairs of the Academy; 11 pages to advertising; and 27 pages to announcements, book notices, index, and routine journal copy. Of 63 books received, 44 notices were published according to Dr. T. H. Langlois, the Book-Review Editor.

The symposium on Forest Tree Physiology was published in the November issue; it contained seven separate papers.

Respectfully submitted,

HENRY L. PLAINE, *Editor-in-Chief*

REPORT OF THE DIRECTOR OF PUBLIC RELATIONS

The first year in office of the new director was chiefly one of finding the way. With the very fine assistance of the people in the News Bureau at Bowling Green State University, a pattern of news releases was established. Six releases were sent out to about 175 newspapers and other interested parties throughout the state. Without subscription to a clipping service there is no way of discovering the effect of the coverage. The material is there; all we can can do is hope that some will use some of it.

Invitations to the meetings were sent to all these parties. Abstracts and copies of *some* papers are being made available to the press. It was the understanding of the director that all sections were required to have abstracts available this year, yet only about half of the sections responded to the director's (admittedly belated) request for copies of these abstracts. It is recommended that future instructions to the Executive Vice-Presidents include the submission of 20 copies of all abstracts to the director of public relations at least 10 days before the meeting. It is also recommended that all special speakers or panels, including the president, submit full copies of their papers in the same manner.

A budget of $75.00 was provided for public relations this year. $38.25 was spent on postage. $51.00 was spent on typing. $3.00 was spent on mimeographing. This is a total of $92.25. The treasurer was kind enough to permit the overage. Even so, an additional sum was spent on the work involved. Therefore, it is recommended that the budget for next year be $125.00.

One further recommendation is made. The major reaction from the press is most favor-

able toward the symposia and major addresses. Therefore, this year's program is considered a very superior one from the standpoint of publicity posibilities. Favorable comment has also been received from members of the Academy. It is therefore recommended that this trend be encouraged, even to the extent of provision of expense money for outstanding speakers, perhaps on a rotating basis among the sections.

Respectfully submitted,

JOHN R. COASH, *Director of Public Relations*

REPORT OF THE EXECUTIVE SECRETARY OF THE JUNIOR DIVISION, OHIO ACADEMY OF SCIENCE

This report covers the tenth year of activities of the Junior Division of The Ohio Academy of Science. The year's operations were characterized by the expansion of programs stipulated by the constitution (District Science Days; State Science Day; Newsletter; Scholarship Tests; Teacher Awards; and Special Awards); and the initiation of several new ideas (Local Science Days; Science Clubs; Brochures; and Insignia). It has proven to be an extremely active first year for the present Executive Secretary.

An eighth district was established with its center at Heidelberg College, Tiffin, Ohio. The new district embraced an area previously serviced by Northwest, Central and Northeast districts, and included the following counties: Ottawa, Sandusky, Seneca, Wyandot, Marion, Morrow, Crawford, Huron, Erie, Lorain, Ashland, and Richland. Professor A. G. McQuate was appointed University Councilman, and Donald Kingsmore was elected High School Councilman. The First District Science Day was held March 29, 1958, with 684 students participating. The District Committee is interested, enthusiastic and capable.

A grand total of 4934 Junior and Senior High School students participated in the eight district science days. This represents an increased participation over 1957 of 1378 students. This figure is not a true indication of the increased interest shown by teachers and students in the Science Day Program because of definite steps taken by some districts to limit the number of projects. Central District restricted the number of entries from individual schools to five percent of the enrollment. This measure was effective in limiting the number of participants to the better projects and encouraged the establishment of several Local Science Days. A brief summary of 1958 District Science Day participation follows:

March 22—Southeast, Ohio University	295
—East, Muskingum College	217
—Central, Ohio State University	647
—Southwest, Miami University	651
—West, Wittenberg College	522
—Northwest, Bowling Green State University	1263
March 29—Northeast, Kent State University	655
—North Central, Heidelberg College	684

The 1958 State Science Day was the largest in the ten year history of the Junior Division. 877 students involving 789 projects registered. A record of 233 schools were represented by participants.

Daniel Friedberg, Leetonia, Ohio continued as Editor of the Newsletter. He was ably assisted by the editorial board with Mrs. Clara Kenny as chairman. Dr. Frederick H. Krecker supervised the printing and distribution of three issues of 5000 copies each. The fourth issue is scheduled for May, but will be delayed until October. This should serve as an impetus for initiating project activity for the 1959 program. The 1958 Newsletter was printed according to the style and format inaugurated last year.

The psychological service of Akron University administered the Scholarship Tests this year. More than 80 applications for testing were received. Mr. William Hornbrook, Eaton, Ohio has contacted the participating colleges and universities and has received renewed commitments from most of them.

An amendment to regulations has been introduced to permit the awarding of *either* A.A.A.S. membership *or* membership in the scientific society of field of interest to Outstanding Teachers. Dr. Mildred Miskimen, Miami University, is chairman of a committee which is studying and re-evaluating the procedures and criteria for the selection of Outstanding Teachers. A list of the Outstanding Teachers elected for the year 1958 follows:

Southeast	—Mr. Richard H. Essex, Athens Junior High School
East	—Mr. Fred Reynolds, Bellaire High School
Northeast	—Mr. Robert E. Stevens, Lincoln High School, Canton, Ohio
North Central	—Mr. Harold Freshwater, Lorain High School
Central	—Mr. Joseph A. Ralston, Westerville High School
Southwest	—Mr. T. Hadley Diehl, Cincinnati
West	—Mrs. Margaret Oswalt, Jackson Local (Darke Co.) Union City, Ind.
Northwest	—Miss Eleanor Longbrake, Scott High School, Toledo, Ohio

The Kroger Company has agreed to extend the award to include the newly formed North Central District effective in 1958. Mr. Irwin Slesnick, University School, Ohio State University, Chairman of the Special Awards Committee, has continued the revision of procedures and criteria for determining the award winners. Effective this spring, the awards will be presented in the same calendar year for which they were won.

A listing of the 1957 Kroger Award Winners follows:

Southeast	—Fort Frye High School, Beverly, Ohio
East	—Belle Valley High School
Northeast	—Thomas W. Harvey High School, Painesville, Ohio
North Central	—Not eligible in 1957
Central	—Westerville High School
Southwest	—Wilmington High School
West	—Blume High School, Wapakoneta
Northwest	—Fostoria High School

A program of affiliating local Science Days with the Junior Division was inaugurated this year. In the face of numerous requests for aid and advice in planning and operating science days, it seemed advisable to strengthen the relationship between the Junior Division and various high schools. In order to affiliate, the Director of the local science day agrees verbally to use Junior Division Standards, Criteria and Ratings, and to select projects from the local science day to participate in the District Science Day. In return, he is eligible for aid and advice from the Junior Academy. The Junior Division will furnish supplies in the form of entry cards, award certificates and membership cards. Certificates of affiliation signed by the president of the Academy have been issued to each of the following: Perrysburg Science Night; Liberty Center Science Fair; Fostoria Science Day; Jackson-Junior Science Fair; St. Mary-of-the-Springs Science Fair; Bishop Watterson Science Fair; Scio Science Fair; Great Northern Science Association Science Fair; Champaign County Science Fair; Morrow County Science Fair. The general trend seems to include the elementary grades in the science day program at local school level. Morrow County and Westerville included all 12 grades in their fairs. The results of this program of affiliation have been most gratifying. The reaction of the public to these local science days has been amazing. Estimated attendance at the Morrow County Science Fair is more than 10,000.

The brochure authorized for the Junior Division is in the final stages of preparation. Work has been temporarily suspended until vacancies in the Junior Division Council have been filled.

An effort has been made by Fred Reynolds, Bellaire, to secure a distinctive, pin-type insignia for distribution to members of the Junior Division. A local branch of Clevite Corporation was awaiting approval of the main office before proceeding to make the dies. No further information has been received. Dr. Richard A. Popham, Ohio State University, made contact and received samples from a Columbus firm. Roulet Jewelers of Toledo are interested in the project. Progress to date has been slow but work is proceeding.

Changes in Administrative regulations have been approved as follows:

a. Papers limited to 2000 words or less
b. Each student limited to one entry.

The following changes in University Councilmen are announced:

a. Dr. William E. Wilson replaces Dr. Mildred Miskimen, on leave, at Miami.
b. Dr. W. Hugh Barnes, Muskingum College, to be replaced (College Rotation Policy)
c. Dr. Robert Ingham, Ohio University, to be replaced (resigned).

Owens-Illinois Glass Company of Toledo donated 700 sets of souvenir glasses for distribution to State Science Day participants.

Mr. Joseph Krauss, Director of National Science Fair, appeared before the Junior Division Council to ask for affiliation of the Junior Division with Nation Science Fair. Dr. John Crites, Ohio State University, was appointed chairman of a committee to study his proposal. The committee recommended against affiliation and was upheld by the Junior Division Council.

Your Executive Secretary and Assistant Executive Secretary attended the annual meeting of the Academy Conference at Indianapolis in December. The Ohio Academy can feel justly proud of the accomplishments of its Junior Division.

In spite of the increased load of nearly one thousand pieces of outgoing correspondence, several circuit riding speeches, over 2000 miles of travel, and constant defense of policy, it has been an interesting and inspiring year. One hundred percent cooperation of all council members has added to my pleasure.

Respectfully submitted,

GERALD ACKER, *Executive Secretary*

REPORT OF OHIO FLORA COMMITTEE

Preliminary list of Compositae, by Robert W. Long, appeared late in spring of 1957. This list includes 449 names. Work on this large family is continuing; this part of the Vascular Flora of Ohio will be prepared jointly by Robert W. Long and T. Richard Fisher.

Work on Grasses of Ohio continues; this will be a section of that part of the Flora concerned with the Monocotyledoneae, which, it is planned, will be the next Part.

Woody Plants of Ohio:

Text (465 pp., exclusive of glossary and index) completed, and being critically checked. Large proportion of checking of herbarium specimens has been completed, but some very complex genera remain. The specimens that are checked will be the basis for mapping distribution. Illustrations of species about 85% completed. Publication is being investigated.

Respectfully submitted,

E. Lucy Braun, *Chairman*

REPORT OF THE COMMITTEE ON THE TRAINING AND CERTIFICATION OF SCIENCE TEACHERS

The specific undertaking of the Committee as requested by action of the Council, was to take up in order and discuss the "Laws and Regulations Governing the Certification of Teachers. . . ." as published in the "little orange book" put out by the State Department of Education on January 1, 1955. The page references which follow, all refer to pages in the "little orange book."

The Committee did its work this year by correspondence. This method was used: (1) because of the long travel distances to a central meeting place necessary for several committee members, (2) the illness during a part of the time of the chairman, and (3) the thought and hope that about as good results could be obtained by the correspondence method at a considerable saving of time, energy, and expense.

The Committee has surveyed some seven Committee reports and has found that these reports all agree that around 60 semester hours or approximately one half the number of hours for the degree should be in subject matter or content material aside from work in general education and professional courses.

The present requirement in science for the certification of elementary teachers (p. 18) is 8–12 semester hours. The majority of the Committee (7 out of 10) think that this minimum is too low; a minimum of 24–28 semester hours will be better—12–14 hours of biological science and 12–14 hours of physical science which must include some Astronomy and some Geology. The elementary teacher holds a key position in the present crisis in science teaching.

The present certification requirement for teaching biology in high school is 15 semester hours of biology (p. 22). This requirement ranks Ohio very low among the other states in the nation. The majority of the Committee (8 out of 10) thinks that the minimum requirement of 15 semester hours is too low and recommends that the requirement be raised to around 30 to 35 hours with supporting courses in chemistry, physics, geology and astronomy. When all aspects of biology are considered it is as broad a subject as physical science and should claim as much time.

The present certification requirement for teaching General Science in the Junior High School (p. 23) is 21 semester hours in physics, chemistry, and biology. All members of the Committee agree that this minimum requirement is too small and that more science should be required. Four out of ten think that 30 semester hours should be required, including work in astronomy and geology. Four think that 45 to 60 hours should be required. Two think that ultimately the general science certificate should be dropped and the teacher should earn the broad Comprehensive Certificate. We shall return to this later.

The present certification requirement for the comprehensive science major for High School Science Teaching (p. 26) is a total of 45 semester hours. Of this total, 36 semester hours are to be taken in biology, chemistry, and physics—20 semester hours in one, and 8 semester hours in each of the other two. The excess 9 semester hours is to be invested in astronomy, geology, meteorology, physiography, or mathematics. None of the Committee think that 45 semester hours in science are enough. They all (10 of them) voted a comprehensive science major of 60 hours of science. The Committee divided 4 to 6 on the kind of 60 hour comprehensive major preferred. Four prefer a major that has both breadth and, in one subject, depth. The other six prefer a comprehensive major of breadth, but without much depth anywhere. We shall return a little later to these possible two kinds of comprehensive majors.

The present certification requirement for the Physical Science Major for High School Teachers (p. 26) is 21 semester hours made up of basic courses in both physics and chemistry. All of the Committee voting agreed that 21 semester hours is not enough. Eight agree that a minimum of 32–35 hours in physics and chemistry be required, plus supporting electives in science and mathematics to total 60 hours. Some favor making all the electives to make 60 hours in science, assuming that there will be prerequisite in mathematics required by the courses in physics. Two of the ten favor requiring a comprehensive major for these physical

science majors that have both breadth and, in the physical science, more depth, even if the total required hours go above 60.

Let it be noted that on the part of a small number (2) of the Committee, the ultimate elimination of certificates in general science, physical science, and possibly biology is favored. The idea is that future general science teachers might take Comprehensive Major A which would be composed of 60 hours of breadth, but not necessarily depth. The future physical science and possibly the biology teachers would take Comprehensive Major B, which would be made up of 60 semester hours or more and would have breadth and at the same time have more depth in either physics, chemistry, or biology.

In response to my request for ideas, various Committee members sent in ideas which, when later sent out for the entire Committee to read, received much approval from some of the other members of the Committee. Some of the ideas are: (1) We, in science, should work cordially with the people in the field of education on this important problem: (2) We should talk strongly for *more* science rather than for less education; (3) We should be constantly working to improve our science courses for teachers—many science courses designed for training chemists, physicists, doctors, geologists, etc., are possibly not best for teacher training—many of them are too specialized; (4) We still have the problem—a very real one— of working out proper courses in science for the fifth year of work, for both elementary and high school teachers—work that can be used for graduate credit.

Respectfully submitted,

HARRY A. CUNNINGHAM, *Chairman*

REPORT OF THE ACADEMY HISTORIAN

Since the publication of William H. Alexander's history of the Ohio Academy of Science (*Ohio Journal of Science* 41(4): 288–312. 1941), there has been no summary of major events and officers. This report brings up to date the changes which have taken place in the sectional organization of the academy and a review of the annual meetings with a listing of major officers.

I. Changes in the Organization of Sections

1942—Section of Anthropology organized.
1943—Name of Section of Botany changed to Plant Sciences.
1947—Name of Section of Junior Academy changed to Science Education.
1950—Name of Section of Anthropology changed to Anthropology and Sociology.
1951—Section of Conservation organized.
1953—Subsection of Genetics organized.
1954—Sections of Psychology and of Mathematics discontinued.

II. REVIEW OF ANNUAL MEETINGS AND PRINCIPAL OFFICERS, 1941–1958

Time and Place of Annual Meeting	President	Secretary	Treasurer
1941 Western Reserve Univ. and Case School of Applied Science Cleveland	Stephen R. Williams	W. H. Alexander	Edward S. Thomas
1942 Denison University, Granville	Eugene Van Cleef	A. W. Lindsey	" "
1943 Ohio State University, Columbus	Frederick H. Krecker	" "	C. E. Taft
1944 " " " "	H. C. Shetrone	" "	" "
1945 No meeting held			
1946 Ohio State University	J. Ernest Carman	" "	" "
1947 Marietta College, Marietta	H. H. M. Bowman	Rush Elliott	W. M. Tidd
1948 University of Toledo	A. W. Lindsey	" "	" "
1949 Denison University, Granville	George B. Barbour	" "	" "
1950 Capital University, Columbus	Paul B. Sears	" "	Robert M. Geist
1951 Miami University, Oxford	Edward S. Thomas	" "	" "
1952 Kent State University	W. H. Shideler	" "	" "
1953 Ohio State University	G. W. Blaydes	" "	" "
1954 Ohio University, Athens	R. A. Hefner	" "	" "
1955 Ohio Wesleyan University, Delaware	Rush Elliott	Ralph W. Dexter	" "
1956 Wittenberg College, Springfield	Paul Rothemund	" "	Elton F. Paddock
1957 Bowling Green State University	Robert M. Geist	" "	" "
1958 University of Akron	Walter C. Kraatz	George W. Burns	" "

An effort is being made to bring up to date statistical data concerning the development of the academy and to accumulate records of historical importance for the permanent files of the academy. The academy historian is beginning a series of brief reports to the various sections on the historical development of the academy and of the respective sections.

Respectfully submitted,

RALPH W. DEXTER, *Chairman*
Committee on Academy History

REPORT OF THE RESOLUTIONS COMMITTEE

Be it resolved that the members of The Ohio Academy of Science express to the Administration of Akron University, to Dr. Walter C. Kraatz, chairman of the local committee on arrangements, and to the several members of his committee, their appreciation of the excellent facilities and thoughtful hospitality which have contributed greatly to the success of this, the 67th annual meeting of the Academy.

Respectfully submitted,

RALPH V. BANGHAM, *Chairman*

REPORT OF THE NECROLOGY COMMITTEE

for the Period of April, 1957 to April, 1958

During this interval only one member died. This is the smallest number of deaths within the memory of the chairman, whose acquaintance with Academy affairs covers a seventeen year span. The necrology report for 1956 recorded ten, while the 1957 report contained eight obituaries.

Respectfully submitted,

J. T. MADDOX, *Chairman*

CHARLES HENRY BOWEN

District Geologist, U. S. Atomic Energy Commission, Grand Junction, Colorado. Fellow of the Geology Section of The Ohio Academy of Science.

Dr. Bowen was born in Creston, South Dakota, January 20, 1911 and died of a coronary thrombosis January 4, 1958, at Monrovia, California while on a vacation with his family.

After graduating from Glenville High School, Cleveland, Ohio he attended the South Dakota School of Mines and Technology at Rapid City, graduating in 1935 with a degree of Bachelor of Science in Mining Engineering with a geology major. He obtained his master's in 1947, and his doctor's degree in 1952, both from The Ohio State University. While at Ohio State he was at various times, graduate assistant, worked with the Ohio Geological Survey, and was a research assistant professor in the Engineering Experiment Station of The Ohio State University. Since 1955, he was connected with the Atomic Energy Commission. He was the author of twenty-some papers published in engineering journals or by the Ohio Geological Survey. During World War II, he was a sergeant in the U. S. Army Engineers, serving both in the European and the Southwest Pacific theaters of operations.

Dr. Bowen was a member of: American Institute of Mining, Metallurgy, and Petroleum Engineering; Geological Society of America; Society of Economic Paleontologists and Mineralogists; Sigma Xi; and a Fellow of The Ohio Academy of Science. He was active in the local Grand Junction Geological Society.

He is survived by his widow the former Anita Schenck, also a member of the Academy, and two small sons, Charles Randall, age 4 and Keith Henry, age 2.

Cold Spring Harbor Symposia on Quantitative Biology. Population Studies: Animal Ecology and Demography. Vol. 22. xiv+437 pp. 41 authors. $8.00.

This is a report on meetings of about 150 scientists held in June, 1957. The purpose of the session was "to bring together in the informal setting of the Biological Laboratory ecologists, demographers, anthropologists, population geneticists, and mathematicians to discuss research problems, experimental procedures, and analytical techniques of common interest to the fields of ecology and demography." Discussions were held on an extensive range of subjects, including the historical aspects of human populations, the demographic theory, the associations of diverse types of individuals or groups of species in communities, and the use of newer mathematical concepts in clarifying the statement of problems.

The series of separate articles have been grouped for coherence in sections, and the titles of these sections do not quite agree with the list of subjects discussed. There are three sections devoted to studies of the Ecology of Natural Populations, one on The Structure of Communities, and one on the Population as a Unit of Evolution. The discussions were summarized by Prof. G. Evelyn Hutchison, in concluding remarks which carried beyond any of the materials presented in the series of papers. A noteworthy contribution to the thinking of ecologists, this book should be found on the shelves of all college and university libraries.

THOMAS H. LANGLOIS